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SOURCES OF FEED AND THE IMPURITIES CONTAINED

WATER for boiler feed comes most commonly from streams, reservoirs or wells. The materials found in it vary, of course, with the source of the water and, in the case of streams, with the season of the year and the kind of weather. Also, if the stream is one into which sewage is discharged, the foreign matter will vary with the quality of the sewage and the amount.

Streams

When the rainfall is good, there will be comparatively little rubbish in the stream and the earthy salts in solution will be less; in times of low water, there will be more earthy matter in the water, and the slower rate of flow gives more time for the dissolving of mineral matter. In times of flood, there will be a large amount of rubbish, such as sticks and leaves.

BULGING OF PLATE DUE TO SCALE COVERING EYE BRACE CORRODED BY ACID IN FEED WATER
SCALE FORMED ON BOILER SHELL NEAR HEAD

From quick flowing streams, the chief danger to be feared is the presence of vegetable and animal matter, which will generate organic acids to corrode the boiler and heater and piping. Such acids and also mineral acids and mineral salts are likely to be found where sewage is in the water, especially if it comes from factories. Chemical reaction in the animal matter is also likely to set free oxygen, which will attack the boiler plate and cause serious pitting. Sewage from factories often contains oil and grease also, but these will float on the surface of the stream so that they will be apparent and can be avoided by taking the feed from well below the surface.

Earthy matter is mostly insoluble, can be easily removed by straining and filtering, and does no particular harm of itself except to fill up the boiler. It may be cemented together by other matters so as to become serious. Vegetable matter, unless in such condition as to yield acids, may even help to prevent the formation of hard scale by separating the deposit of minerals. Animal matter and sewage is almost sure to contain acids, and oil and grease coat the heating surface so that it does not readily transmit heat, and if there are minerals in the water, the grease will often combine with them to make a hard scale, which will bake onto the plates of the boiler.

TABLE I. IMPURITIES IN STREAMS. GRAINS PER GALLON

RIVER ANALYSES					
SOURCE	ANALYST	GRAINS PER GALLON			
		CORRODING	INCRUSTING	ORGANIC	TOTAL
SYRACUSE N.Y.	C.F. CHANDLER	3.44	22.58	0.34	26.36
CLYDE R.	" "	2.10	14.30	1.88	18.28
ROCHESTER N.Y.	" "	1.18	10.85	1.64	13.67
MERRIMAC RIVER-MANCHESTER	S.D. HAYES	———	2.96	2.60	5.56
CONNECTICUT R. HOLYOKE	" "	———	1.81	1.39	3.20
ALLEGHENY R.	———	0.37	4.73	1.50	6.60
MONONGAHELA R.	———	0.78	6.82	3.20	10.80
WISCONSIN R. MILWAUKEE	———	20.14	12.66	6.50	39.30
BAY CITY R. MICH.	———	3.00	165.28	10.92	179.20
OHIO R. CINN.	———	———	6.45	0.28	6.73
MISS. R. ABOVE MISSOURI	———	———	9.76	5.25	15.01
MISS. R. BELOW MISSOURI	———	1.22	19.41	15.86	36.49
MISS. R. ST. LOUIS	———	1.37	18.12	9.85	29.34
HUDSON R. ABOVE POUGHKEEPSIE	———	10.76	1.17	0.77	12.70
SCHUYLKILL R. ABOVE PHILA.	———	1.30	2.94	———	4.24

From mountain streams the water is usually pure and needs no treatment other than straining and filtering. It is not safe to assume this just because the water "looks all right," but watching the boilers will tell the story. With sewage, extreme care must be taken and frequent analyses made, as the impurities are likely to change frequently, and the treatment must be changed accordingly. Near the mouth, the river is always more dangerous than near the source, and if there is a tidal action, the salt from the ocean will make the water unsafe for 5 miles from the seashore. Herewith is given Table I, showing the grains per gallon in a number of river waters, but it should be remembered that this can be taken only as an indication of what is likely to be found, not as a basis for the treatment of any particular sample of water, for the quality is sure to vary from year to year even in the same locality.

Reservoirs

Because of the time to settle and the mixture of water which has come in at different times and from different streams, the quality of reservoir water is usually quite uniform, though if the storage capacity is small, flood time will bring a large amount of rubbish.

There may be salts in solution, but they will not be likely to change and a treatment once rightly devised will be good for a long period. Table II shows the composition of various reservoir waters.

Wells

Wells give the greatest amount of soluble matter as the water has all leached through the soil and has taken up the maximum possible amount of mineral matter. The amount of matter held in solution will vary with the depth of the well and the character of the soil. In mountainous and rocky regions, the well water may be almost pure, while in limestone country it will be very hard. This term hardness refers to the amount of matter which is dissolved, and has no relation to the matter floating in the water, so that a water which looks pure and sparkling may be the very worst possible for feeding boilers. The impurities are known as incrusting solids, since they are dissolved in the water, and are deposited on the plates of the boiler as a crust. If the well is shallow and so situated that drainage from privys finds its way into it, an ammonia compound will be formed, which will be very hard on the boiler. Table III gives the composition of various well waters.

TABLE II. IMPURITIES IN RESERVOIR AND LAKE WATERS. GRAINS PER GALLON

SOURCES	ANALYST	CARB.	SULPH.	TOTAL
BINGHAMTON N.Y.	SCAIFE	3.62	3.08	6.70
BOULDER COL.	"	5.65	7.05	12.70
CANTON O.	"	1.85	26.05	27.90
HARRISBURG PA.	"			12.13
HARTFORD CY. IND.	"	16.11	22.45	38.56
L. MICH. MILWAUKEE	"	4.50	3.67	8.17

SOURCE	ANALYST	MINERAL	ORGANIC	TOTAL
SYRACUSE N.Y.	C.F. CHANDLER	27.93	———	27.93
L. ERIE BUFFALO	———	9.56	0.18	9.74
BALTOMORE MD.	———	3.52	3.80	7.30
SIOUX CITY IA.	———	23.20	4.40	27.60
SPRINGFIELD ILL	———	24.55	8.62	33.17
CROTON RES.-N.Y.	———	3.72	———	3.72

TABLE III. IMPURITIES IN WELL WATERS. GRAINS PER GALLON

SOURCES	ANALYST	SOLIDS	ORGANIC	TOTAL
ROCHESTER N.Y.	CHANDLER	40.57	1.60	42.17
PORTLAND ME.	HAYES	13 35	5.13	18.48
WOBURN MASS.	"	51.32	4.60	56.12
CARRIZO SPR. TEX.	"	———	———	1306.18
PITTSBURG PA.	"	48.61	0.82	49.43
ALBANY N.Y.	SCAIFE	———	———	48.69
BOSTON MASS	"	———	———	44.46
BROOKLYN NY.	"	CARB.	SULPH	48.83
BUFFALO N.Y.	"	33.71	134.12	167.83
CHICAGO ILL.	"	32.16	55.92	88.08
DAYTON O.	"	———	———	58.50
DETROIT MICH.	"	———	———	116.46
FT. WAYNE IND.	"	14.37	47.43	61.80

SOURCES	ANALYST	CARB.	SULP.	TOTAL
INDIANAPOLIS	SCAIFE	1.57	36.85	38.42
JOLIET ILL.	"	15.67	39.91	55.58
OMAHA NEB.	"	14.43	59.22	73.65
OSWEGO N.Y.	"	10.93	———	52.10
PROVIDENCE R.I.	"	———	———	33.02
ST. LOUIS MO.	"	16.82	38.15	54.97
SPRINGFIELD ILL.	"	12.12	44.25	56.37
SIOUX CITY IA.	"	15.31	42.41	57.72
STOCKTON CAL.	"	12.95	80.11	93.06
LOS ANGELES	"	3.72	19.35	23.07
WASHINGTON D.C.	"	2.87	5.73	8.80

Returns.

Where water is scarce, and for the sake of economy in heat, the returns from engines and heating coils are often used for boiler feed. This is free from mineral salts and rubbish, but if not carefully treated may contain oil and pipe scale.

Ocean Water

Seldom will this be used in stationary plants, but it

is often necessary to use it in marine boilers. The salt itself does no particular harm except to fill up the boiler and make the water harder to boil because of the greater density. If, however, the salt gets in contact with a dry hot plate, it may bake on and cause trouble. There are always in sea water considerable amounts of chlorides, and these if decomposed in the boiler will give up chlorine gas, which is very active in producing corrosion. Analysis of sea water gives the following, which is approximately correct for all locations except near the mouths of large rivers:

Carbonate of lime.....	9.75	gr.	per	gal.
Sulphate of lime.....	114.36	"	"	"
Sulphate of magnesium.....	134.86	"	"	"
Chloride of magnesium.....	244.46	"	"	"
Chloride of sodium.....	1,706.00	"	"	"

FIG. 4. TUBE PITTED BY OXYGEN FROM PURE WATER

Troubles from Impurities

These may be summarized as pitting and grooving, corrosion, incrustation, overheating, foaming. Pitting is the formation of conical or spherical pits, filled with a yellowish brown powder or empty, and caused by the action of oxygen released from the water as it is heated, or from organic matter, and by chlorine, which is released from organic matter, from sea water or from magnesium chloride. Pitting is most active at moderate temperatures, and as the gases are released on heating it is most common near the inlet to boiler or heater. It seldom comes in the steam space, except when a boiler is left standing so that it sweats and the drops of water stand on the shell. In such cases it may take place on the outside as well as on the inside, especially if a coat of ash and soot is left on the boiler surface.

Water always contains some air in solution, and in this the oxygen is more concentrated than in free air, for oxygen is more soluble than hydrogen; the proportion in free air is 1 to 4 and in dissolved air 1 to 1.87. When this dissolved air is released, it attacks the iron, and sometimes in the case of water which is too pure, so that there are no mineral salts for the oxygen to act upon, serious pitting of the boiler will take place from this action alone. Water from peaty soil and swamps is charged with acids, which will cause pitting if not neutralized by some alkaline salt.

Grooving is of the same nature as pitting, but takes place at some point in the shell where there is a local bending or stress, which makes the metal specially liable to attack. It is found most frequently at the seams or at a bend in the plate which goes and comes with expansion and contraction. These forms of injury are especially dangerous as they are local, may be covered by scale and are hard to locate without careful examination; also they weaken the shell locally in a way that is likely to start a crank and result in an explosion. They should be watched for and guarded against as much in a live steam heater and in piping as in the boiler, for the explosion or giving out of a heater or pipe may cause death and damage as well as shutting down a plant, and the corrosion is particularly active just when the water is first heated.

Corrosion

It is similar in nature to pitting and grooving, but is widespread, and is due to acids in the water, which attack the whole surface of the shell. These acids come from animal matter, sewage from mills, acid scale and sulphur from mine waters. In some cases galvanic action causes an electric current, which induces corrosion, but this is generally local in character. Sulphur in the water causes the formation of sulphuric acid; carbonic acid gas from the rotting of organic matter will attack the iron when released from solution; magnesium chloride is a cause of corrosion, though the exact method of its action is a matter of dispute. In all such cases the acid must be killed by the addition of some base, such as soda ash or limestone, sufficient to make the water slightly alkaline. Too much will cause foaming and make a needless amount of deposit to be blown down. Sulphuric acid is used to purify kerosene oil, and where such oil is used in boilers, there has sometimes been enough of the acid left to cause corrosion.

Incrustation.

Throwing down of soluble salts and suspended matter from the water in the boiler is the cause of this trouble, which is one of the most bothersome encountered. The incrustation may be loose so that it is easily washed out, or it may be hard so that only the hardest kind of work will take it off the surface.

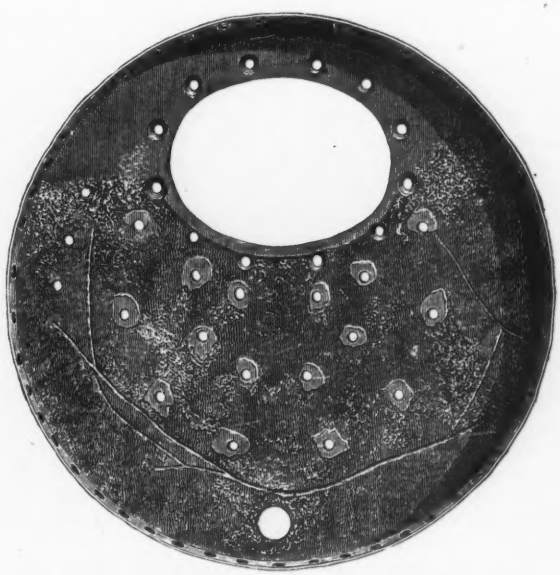


FIG. 5. BOILER HEAD CORRODED BY MINE WATER

The floating matter is usually of the former kind unless it is cemented together by hard scale or is oily in nature; then it becomes a hard mass, which keeps the water away from the surface of the plates, resulting in loss of heat and sometimes in overheating of the plates. The amount of such incrustation depends on the hardness, which is of 2 kinds; that which disappears when the water is heated to 212 deg., and that which continues up to high temperatures. The former, called "temporary hardness," is due to the carbonates of calcium and magnesium which are dissolved in water charged with carbonic acid gas. When this gas

is driven off by heating to 212 deg. the carbonates become insoluble and are deposited in the bottom of the containing vessel. These carbonates are light so that they settle only slowly and may be carried for a long time in a current of water before they are finally dropped. When they do fall, they form a loose powder, which is easily washed out of the boiler, unless they are combined with oil or grease.

The second form of hardness, called "permanent," is due to sulphates, chlorides and nitrates of calcium and magnesium. These are thrown down at 300 deg. so that the hardness is really not permanent, nor is all

TABLE IV. SOLUBILITY OF SUBSTANCES IN PURE WATER

SUBSTANCE	AT 60°F		AT 212°F.	
ALUM POTASH ALUM	0.792	LBS.	29.8	LBS.
ALUMINIUM SULPHATE	2.75	"	7.42	"
AMMONIUM OXALATE	0.375	"	3.4	"
BARIUM CHLORIDE	2.92	"	6.0	"
" HYDRATE	0.417	"	0.83	"
CALCIUM CARBONATE	2.09	GRAINS	1.25	GRAINS
" CHLORIDE	33.4	LBS.	UNLIMITED	
" HYDRATE	77.6	GRAINS	44.7	GRAINS
" NITRATE	33.4	LBS.	UNLIMITED	
" OXIDE LIME	58.4	GRAINS	33.8	GRAINS
" SULPHATE	134.5	"	126.8	"
FERROUS SULPHATE	1.87	LBS	14.85	LBS.
MAGNESIUM CARBONATE	DOUBTFUL		1.25	GRAINS
" CHLORIDE	16.7	LBS.	33.4	LBS.
" HYDRATE	1.67	GRAINS	1.67	GRAINS
" OXIDE	1.17	"	1.17	"
" SULPHATE	2.50	LBS.	10.83	LBS.
SODIUM BIBORATE BORAX	0.334	"	4.59	"
" CARBONATE DRY	1.00	"	3.75	"
" " CRYSTALS	3.92	"	11.70	"
" CHLORIDE	2.92	"	3.34	"
" HYDRATE	5.09	"	UNLIMITED	
" HYPOSULPHITE	4.17	"	16.7	LBS.
" PHOSPHATE	1.00.	"	16.7	"
" SULPHITE	2.095	"	8.33	"
" SULPHATE	0.915	"	3.5	"

the "temporary" hardness deposited at 212 deg. Both are relative terms. These salts are commonly known as follows: Carbonate of calcium is limestone, marble or chalk; magnesium carbonate is magnesia; calcium sulphate is gypsum or plaster of Paris; magnesium sulphate is Epsom salts; magnesium chloride has no common name; sodium carbonate is washing soda or soda ash; sodium chloride is common salt; oxide of iron or iron rust and oxide of aluminum are sometimes found in small quantities. The amount of each which can be dissolved in water is shown in Table IV taken from Christie's Boiler Waters.

Scale Formation

Hardness in water is measured by the number of grains per gallon of soluble salts contained. As already stated, temporary hardness is due usually to carbonates and the so-called permanent hardness to sulphates and nitrates. These dissolved solids when thrown down by the heating of the water and left behind by evaporation, form incrustation or scale on the heating surfaces. The amount of scale formed will, of course, depend upon the amount of salts in the water and, therefore, upon the hardness, so that it is important that the hardness or the amount of incrusting solids should be determined.

As an example of the amount of scale which may be formed in a boiler, take the case of a boiler of 100 hp. This will use, at 34.5 lb. of water evaporated per horsepower-hour, 3.450 lb. of water an hour, or 34,500 lb. per day of 10 hrs. A water containing 25 grains per gallon of soluble matter, which is about one part in 4,000, is not uncommon, and such a water would leave behind in the boiler 8.625 lb. per day or 259 lb. a month. In a year this would give 3,108 lb., or 1.5 tons. The importance of adopting some means of avoiding this accumulation of scale is obvious.

Harm from incrustation is due not only to the filling up of the boiler, thus reducing the water and steam space, but also to the greater resistance offered to the passage of heat through the boiler plate. Collet gives as the resistance to heat transmission, taking that of wrought iron as 1, for copper, 0.4; for slate, 9.5; for brick, 16, for chalk, which is the scale formed from carbonates, 17, and for hard scale, such as is formed from sulphates, 48.

C. E. Strohmeyer states that scale 0.1 in. thick in a boiler will offer as great resistance to the passage of heat as a steel plate 10 in. thick. Various estimates have been given of the percentage loss due to different thicknesses of scale, but these are not in agreement with each other and, of course, depend largely upon the kind of scale. It is sufficient to understand that the formation of even a slight amount of scale means a serious loss.

Classifying water as to its value for boiler feed, Silvester gives that with less than 8 grains of incrusting solids per gallon the water is good, with 8 to 15 grains, fair; 15 to 20 grains, poor; 20 to 30 grains, bad; 30 to 40 grains, very bad. This classification should be qualified somewhat, depending upon the impurities contained in the water which go to make up this hardness.

The carbonates which separate out at a temperature slightly above 200 deg. usually appear as light flakes or threads and settle but slowly through the water. When they finally reach the bottom they form a loose powdery deposit which is readily cleaned out unless subjected to high heat or mixed with oil, in which case it is likely to become hard. Vegetable matter, such as bark, sticks and sawdust mixed with the scale, will usually prevent it from cementing together and keep it porous, so that it is easily removed. Earthy matter, on the other hand, especially if it has sand mixed with it, is likely to form a hard scale similar to cement.

Sulphates which are thrown down at a temperature somewhat above 300 deg., usually settle rapidly in water and at the bottom form a hard scale which is difficult to remove. In any case, if the scale is formed in contact with the boiler plate, particularly if the plate be hot, it will stick to the plate and other scale will deposit on that already there, giving a hard crust. As a rule, the scale formed on the plates just over the fire will be the thinnest because the circulation of water is rapid at that point and there is less time for the deposit to form, but the scale there will be hardest because it is formed at the highest temperature and a thin hard scale is often a poorer conductor of heat than a thicker scale, which is porous and allows the water to get through to the plate.

In consequence of this condition, the blowing down of a boiler to remove deposits should be done in the morning or at the end of the noon hour after the water has been quiet so that the scale-forming material has had a chance to settle, and in blowing the water out of a boiler for cleaning or for laying up, if there be scale or deposit in the bottom, the water should not be taken out until this deposit has been removed, as otherwise it will bake hard onto the hot plates. If it is necessary to empty a boiler quickly after taking away the fire, cool water should be run in along the bottom to wash out the deposit before it has a chance to dry.

Blowing down a boiler hot will, of course, leave less mud to wash out, as a considerable part of the so-called mud bakes hard to the plate, but it means more scale to remove later.

As an example of what scale costs in a boiler, R. B. Dole, of the U. S. Geological Survey, gives

the following figures for a typical case on the Maumee River. The total solids amounted to 36 grains in 100,000; the matter in suspension to 10.5 grains, the rest being incrusting solids composed of carbonates and sulphates. Mr. Dole figures that in 6 days a 1,000-hp. boiler plant would gather 1,800 lb. of scale, that the extra coal cost due to this scale would be $1,212 a year, the extra cost for repairs due to overheating, etc., $150, and the depreciation $375, or a total expense of $1,737 a year due to the use of impure water.

C. L. Kennicott stated before the Western Railway Club that the grains of incrusting solids per gallon as found by analysis, divided by 7 gives the weight in pounds of incrusting matter entering the boiler per 1000 gal. water used.

Foaming.

When suspended matter is present in water and, to a certain extent, if oil be present, the surface tension of water becomes greater; that is, it takes a greater force for the bubbles of steam to burst through the surface and escape into the steam space. This results in the carrying up of bubbles of foam above the surface of the water and the churning of the top of the water into bubbles which makes the exact level uncertain and sometimes results in filling the steam space with these bubbles which are carried over into the steam pipe. The foaming is usually laid to the presence of sodium or potassium salts in the water, to oil or grease which form a scum on top, or to fine particles of matter suspended in the water. Of these the floating particles are probably the greatest cause and they may be either particles of vegetable matter or particles of mineral salts when the water has taken up all that it can dissolve.

Experiments by means of a water softening device go to show that for a 2-flue boiler at 50 lb. pressure the sodium sulphate can amount to 1,000 gr. per gal. without causing foaming; for a horizontal tubular at 100 lb. pressure, the sulphate may reach 500 to 600 gr.; for a straight water-tube boiler at 125 lb. pressure, from 300 to 400 gr.; for a curved water-tube boiler at 125 lb., from 250 to 300 gr.; and for locomotive type at 200 lb., from 150 to 200 grains. While the pressures are here given because they are reasonably typical of the kind of boiler employed, the experiments seemed to show that the steam pressure carried had no effect on the amount of floating solids which could be carried without foaming.

Any remedy which removes the floating material from the water is likely to stop the foaming. For vegetable and earthy matters filtering and straining are employed, and frequently surface skimming will be found most effective. For the soluble salts some means of precipitation must be used to get them out of the water.

THE EFFECT OF OIL IN BOILERS

By C. R. McGahey

Some writers have pointed out the advantage of using oil in boilers, but I wish to say at the start, that having had experience in practical work and having used some light oils in the boiler and tested out the effects, I would prefer pure, clean water and no oil for many reasons.

Oil is dangerous in a steam boiler at the best, and from long experience I think that many boilers are damaged by its use. I have seen plates, which were not corroded, bagged down and ruptured by the effect of oil which, in connection with other substances, had formed a hard insulating scale almost impervious to heat. In some instances this was a gray hue, again it would be black and often not more than 1-16 or 1-32 in. thick, yet the plate would get so hot that it would give way. When the boiler had been repaired and the use of oil was stopped, no further trouble was experienced.

This is conclusive evidence to me what effect oil will have in some boilers, but the chemical condition of the water will govern results and in some water there may be a good deal of alkali, which will convert the oil into soap, causing the boiler to foam and doing but little harm. In other cases chemical action will cause a residue, which will settle on the boiler plates and form an insulating coating, and in still other cases the oil may remove a scale already formed, but form another coating far more dense and a much poorer conductor of heat than the one formerly existing. In some cases, of course, a slight amount of oil will do no harm, but I should say emphatically, that except for a little light kerosene, no oil should be allowed in a boiler.

Even a thin film of oil is a great hindrance to heat passage. C. E. Strohmeyer estimates that a film of oil 0.01 in. thick will give as great a resistance as scale 1-10 in. thick or steel plate 10 in. thick, and Christie in his book on Boiler Waters states that a clean steel plate ½ in. thick will have a difference in temperature of 3 deg. between the sides, when evaporating 3 lbs. of water per sq. ft. per hr., while with 0.1 in. of scale the temperature difference will be 60 deg., and with a film of oil it will be greatly increased.

The only time that oil is of great value is when the water is strong in potash and the oil provides a substance for the potash to work on, thus, to a certain extent, protecting the plates from corrosion. It is safe to assume that any agent used in a boiler which causes the scale to flake off from the shell is harmful because in most instances this flaking off is caused by the chemical attacking the plates and thus eating away the surface to a slight degree. For this reason it is not safe to use oil or any other chemical unless you know what the water contains and what the results will be.

Oil mixed with carbonates and sulphates, particularly when it comes in contact with the hot plates, will cause a hard scale, which bakes on, and even where the oil is mixed only with such substances that it becomes a jelly-like mass, this, if allowed to remain long in contact with the hot plates, will become like putty and will be difficult to remove.

The serious effect of oil on the plates is due to its preventing the contact of the water with the plate, so that heat cannot be conducted away by the water. Where oil is contained in the water a method of removing it is by introducing some kind of light flaky material which will gather the oil as a skin on the flakes and carry it to the bottom of the vessel, or the oil after being collected in this way may be filtered out.

For a filtering chamber where the water is passed through sawdust the speed of passage should be slow in order to take out the oil.

N. Sinclair, in an article in Cassier's Magazine, states that water which is filtered once through such a sawdust bed should have an area through which to pass in the filter chamber of 99 times that of the feed pipe; if filtered twice, it should have an area of 60 times the area of the feed pipe, and if filtered three

times, 33 times that area. The Reeves Co. recommend for a feed pipe of ½ in. diameter a filter chamber 3 in. in diameter, and the speed recommended through a filter made of Turkish toweling is, for one passage, 4 to 5 ft. a minute; for 2 passages, 6 to 7.5 ft. a minute; for 3 passages, 12 to 15 ft. a minute.

When a boiler becomes coated with oil, the best remedy to clean it out is to introduce from 10 to 25 lb. of soda ash into each boiler, which will form with the oil on the surfaces a soap, which can be blown out. The soda ash should be put in, the boiler held at a low pressure, approximately 5 lb., for a couple of days and the water then blown down.

Many engineers are studying the water problem and beginning to understand the chemical composition of water and the science of water purification. Such will understand that the throwing of black oil into a boiler will increase largely the amount of coal which has to be burned to evaporate the water needed. We cannot throw anything that happens into our boilers and expect to generate steam on an economical basis and we may do much damage to the boiler in this way.

When foaming occurs it is frequently due to an alkali, and some acid has to be used to correct the evil, but the kind and amount of acid should be prescribed by some chemist who has carefully analyzed the water.

Filtering of water does not remove the dissolved impurities and it is frequently the case that a muddy water may have less injurious matter in it than a water which seems perfectly clear. The steaming capacity of a boiler may be increased 25 per cent by proper care and treatment of the water, and it seems to me that plant owners should study conditions and see that the water is so treated as to make the most steam for the coal burned.

Putting a gallon or so of oil into the boiler before filling, so that the plates may be coated as the water rises to the top, will call for more coal to generate steam, as the oil forms a good heat insulator on the heating surfaces. This oil film may also have a bad effect on the scale formed if there are incrusting solids in the water. In order to get the best results water should be carefully analyzed and treated for the impurities that it contains. Such treatment pays in the labor saved by lessening the scale to be removed and in the saving by increase of heat transmitted through the boiler surfaces, to say nothing of avoiding danger of accident from bagged plates.

ANALYSIS OF WATER

Complete test of water to determine the impurities contained requires extensive knowledge of chemistry and a good deal of skill in chemical manipulation, but it is possible to get a reasonably accurate idea of the main impurities contained by the use of simple apparatus. The tests usually conducted are: for hardness, for acidity or alkaline reaction, for sulphate of lime, for iron, for copper, for carbon dioxide, for total suspended solids, for total dissolved solids, for oils and fats, and for corrosive action.

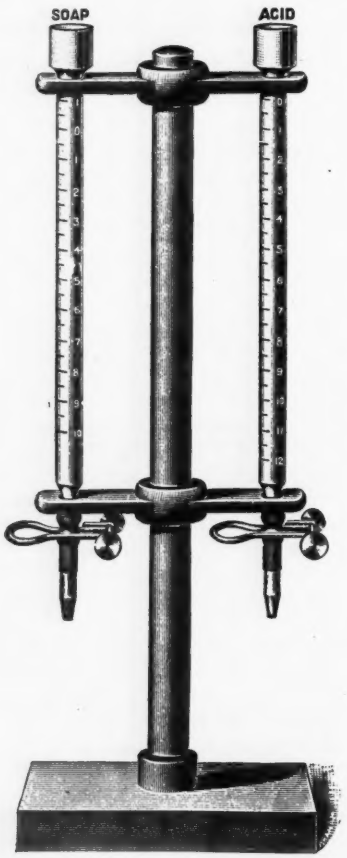


FIG. I. BURETTE FOR MEASURING SOLUTIONS

Soap Test.

Test for hardness is usually made by means of a soap solution. The lime and magnesia salts destroy soap about in proportion to the amount of salts contained in the water, because the lime and magnesia combine with the fatty acids in the soap to form an insoluble earthy compound which will not make a lather. If such a mixture be shaken up no lasting foam will form until the amount of soap added is more than the dissolved magnesia and lime salts can destroy. The soap test is based upon this fact and was devised by Dr. Clark, who was the first inventor of a water softening process.

The first thing necessary to make this test is a standard soap solution. This may be gotten from dealers in chemical supplies and is of such strength that a cubic centimeter has enough soap in it to exactly neutralize 1 milligram of the carbonate of lime in solution. The object of the test is to compare the hardness of the water tested with that of freshly distilled water.

Soap Solution.

To make standard soap solution, 100 grams of the best quality of dry white Castile soap is cut into thin shavings and dissolved in 1000 cu. centimeters of dilute alcohol, the alcohol solution being half 96 per cent. alcohol and half water. This dissolved soap solution is allowed to stand over night to settle. 100 cu. centimeters of the clear liquid are then made up to 2 liters, enough alcohol being used to keep all the soap in solution.

To test the strength of this solution, a standard solution of calcium chloride is made. This is obtained

by dissolving 0.2 of a gram of Iceland spar in dilute hydrochloric acid in a platinum dish and evaporating to dryness; dissolve in a small amount of water and again evaporate to dryness, repeating this several times until all free acid is removed, when the salt remaining is dissolved in a small amount of water and made up to one liter. A cu. centimeter of this solution will then contain calcium chloride equivalent to 0.0002 grams of calcium carbonate and 50 cu. centimeters of this solution should take exactly 14.25 cu. centimeters of standard soap solution to neutralize it.

To test the soap solution 50 cu. centimeters of the calcium chloride solution is put into a flask or bottle of convenient shape and soap solution added about 0.3 of a cubic centimeter at a time, shaking well after each addition until a lather or foam is obtained which will cover the entire surface of the liquid when the bottle is placed on its side and which will last for 5 minutes. If the standard soap solution is of the right strength 14.25 cubic centimeters should neutralize the 50 cubic centimeters of calcium chloride solution. A soap solution, if kept away from the air, will not change perceptibly and will keep for 5 or 6 weeks.

Testing the Water.

In testing water for hardness, 50 cu. centimeters of the water are put into the flask and the standard

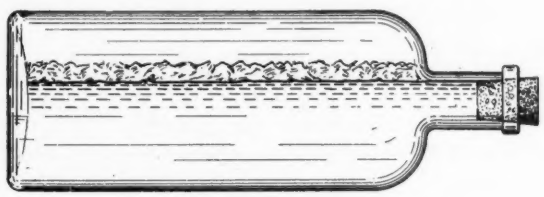


FIG. 2. THE SOAP TEST COMPLETED

soap solution is added 0.3 of a cubic centimeter at a time, as before, and shaken. The hardness of the water as indicated by the soap solution is shown in Table V. The method does not give accurate means of determining hardness above 14 parts per 100,000. If water is encountered having a greater hardness than this, 25 cu. centimeters of the water should be taken and 25 cu. centimeters of distilled water added to make up the 50 cu. centimeters. The parts hardness per 100,000 which is found by the test is then multiplied by 2 because of the dilution of the water.

The soap solution can, of course, be measured in any way, but the most convenient device is a graduated burette, as shown in Fig. 1. As made specially for the soap tests, these usually have one cu. centimeter of soap solution to neutralize the hardness found even in distilled water. In using this burette, it is filled to the top mark with the soap solution and then cock 0.3 cu. centimeter at a time into the testing flask. In reading the height of the solution in the burette the reading should be taken from the bottom of the curved surface or meniscus which will be formed.

The lather will, of course, break down somewhat before the end of the 5 min., but after standing 5 min. there should be a coating of good, stiff lather at least 0.25 in. thick. The time which this lather will last depends partly upon the kind of hardness in the water. The salts of magnesia persist longer than those the solution is drawn out through the bottom stop of lime and are not so quickly neutralized by the soap solution. For instance, if in a water having 10 deg. of hardness, half of this is due to lime and half to magnesia, a heavy lather will be formed when soap has been added to show 7 deg. of hardness, but this lather will disappear after 2 or 3 min. and cannot be produced by shaking again until more soap solution is added. This action gives a means of estimating the relative amount of lime and magnesia in the water. It is always an indication of the presence of magnesia, and approximately the amount of hardness indicated by instantaneous formation of lather is that due to lime and the remaining amount is due to magnesia salts.

TABLE V. HARDNESS OF PARTS PER 100,000, USING .50 CU. CENTIMETERS WATER

C.c. OF SOAP SOLUTION	$CaCO_3$ PER 100,000	C.c. OF SOAP SOLUTION	$CaCO_3$ PER 100,000	C.c OF SOAP SOLUTION	$CaCO_3$ PER 100,000	C.c. OF SOAP SOLUTION	$CaCO_3$ PER 100,000	C.c. OF SOAP SOLUTION	$CaCO_3$ PER 100,000
.7	.00	.8	.99	.2	0.29	.6	.71	10.0	13.31
.8	.16	3.0	.25	.4	.57	.8	10.00	.1	.46
.9	.32	.2	.51	.6	.86	8.0	.30	.2	.61
1.0	.48	.4	.77	.8	.14	.2	.60	.3	.76
.2	.79	.6	4.03	6.0	.43	.4	.90	.4	.91
.4	1.11	3.8	4.29	.2	.71	.6	.20	13.1	18.17
.6	.43	4.0	.57	.4	8.00	.8	.50	.2	.33
.8	.69	.2	.86	.6	.29	9.0	.80	.3	.49
2.0	.95	.4	.14	.8	.57	.2	12.11	.4	.65
.2	.21	.6	.43	7.0	.86	.4	.41	.5	.81
.4	.47	.8	.71	.2	.14	.6	.71	.6	.97
.6	.73	5.0	6.00	.4	.43	.8	13.01	.7	19.13

Testing hardness when magnesia is present is more difficult than when lime alone is found, and greater care must, therefore, be used. In such cases several tests of hardness should be made with different samples of water and it is probable that there will be some disagreement. If water contains vegetable matter the tendency will be for the formation of froth which will make trouble in the soap test for hardness. Also the presence of free carbonic acid gas appears to increase the hardness.

The reason that the soap test is unreliable above 14 deg. of hardness is that after this amount of soap solution has been added to the water the alcohol contained is sufficient to interfere with the lather. Alcohol tends to prevent lathering and after the alcohol gets to be more than 1 part in 4, no permanent lather can be formed. As it approaches this point the interference with lathering becomes greater and 14 deg. of hardness is found to be the maximum amount which can be determined with accuracy. Diluting the water, as mentioned heretofore, is criticized by some chemists but is approved by others and is in general use.

The soap test will not agree closely with careful chemical analysis but gives an indication sufficient for most practical purposes. It does not, however, give an indication of anything except the hardness of the water and should not be depended on where there is any reason to suspect the presence of other minerals than magnesia and lime. When a scum forms on the surface of the water but the body of water below is almost transparent this is not a true lather and should

be disregarded. When the real lather appears the water will be permanently milky and opaque.

ACID TEST.

Preliminary test to determine whether water is acid or alkaline is made by the use of litmus paper. If alkaline, red litmus will be turned blue, if acid, blue litmus turns red. If neutral, neither changes.

The second form of testing for hardness which can be used to show really the alkalinity of the water is conducted by the use of a standard acid solution, and a colored indicator, usually a drop of methyl-orange. This liquid is of a pale lemon yellow when in alkaline liquids and retains its yellow color when acid is added until all carbonates are neutralized, when it becomes a pale orange and any further addition of acid produces a pink or red, depending on the excess of acid added.

To get a test of water for its alkalinity, 200 cu. centimeters are measured out into a porcelain basin and the flask in which the measuring is done is then rinsed with distilled water and the washings added to that in the basin. Two drops of the methyl-orange are added to the water and a standard solution of hydrochloric acid, 1-5 normal strength, is put into the basin from a burette, drop by drop, stirring constantly until the liquid changes from yellow to orange and finally to faint pink. The number of cu. centimeters of the hydrochloric acid solution used from the burette gives the number of parts of calcium carbonate per 100,000 of water. This shows the temporary hardness.

The normal solution of hydrochloric acid for this test is made by taking 40 cu. centimeters of pure concentrated hydrochloric acid, cooling it to 60 deg. F. and diluting it to 1000 cu. centimeters by adding distilled water. This should be labeled "'Standard Acid N-5" and the strength can be checked by weighing out carefully 0.4 gram of the pure carbonate of soda which has been dried at dull red heat in a covered platinum dish, dissolving this in a porclain dish in a small quantity of water, adding a large volume of cold water and then testing with the acid solution for the change from canary yellow to faint pink. If the acid solution is of the right strength, about 20 cu. centimeters of the solution should be required to neutralize the sodium carbonate.

To test for the acidity of water a standard alkaline solution is used, and phenol-phthalein for a color indicator. This liquid is colorless with acids and purplish red with alkalies, so that the standard alkali solution is dropped in, stirring constantly until the permanent purple red color is obtained. The number of cu. centimeters of standard alkali solution used gives the alkali equivalent of the acid present in the water.

The standard alkali solution is made by dissolving 21.5 grams of pure carbonate of soda in 250 centimeters of hot distilled water, the solution then being diluted to 1000 cu. centimeters with cool distilled water and cooled to 60 deg. F. This solution should be labeled "Standard Alkali N-5." When testing the water for alkalinity, the number of cu. centimeters used of the standard acid solution is multiplied by 9.5 to give the parts per 100,000 of water. When testing for acidity the cu. centimeters of standard alkali solution used are multiplied by 9.58.

TEST FOR SUSPENDED SOLIDS.

The method of determining solids in suspension is by filtering out these solids and weighing them. In order to be sure that all suspended matter is removed, a sample of the water is passed through the filter paper. This is a specially prepared paper used by chemists which is porous in character, yet with a fine grain so that it catches all floating particles. Before using, the paper should be dried carefully in a stoppered tube for an hour at 230 deg. F. in a heated oven or air bath. The stopper of the tube is kept out during the drying process, and afterwards put in to prevent the collection of moisture by the filter paper.

The paper before drying should be folded in radiating umbrella fashion to give quick filtration. After drying it is weighed in the tube with the stopper put in to prevent moisture entering, then the paper is taken out and placed in a funnel of the proper size, with as little handling as possible, and 200 cu. centimeters of water are measured and poured through it. Care should be taken that this 200 cu. centimeters is a fair sample of the whole amount of water tested..

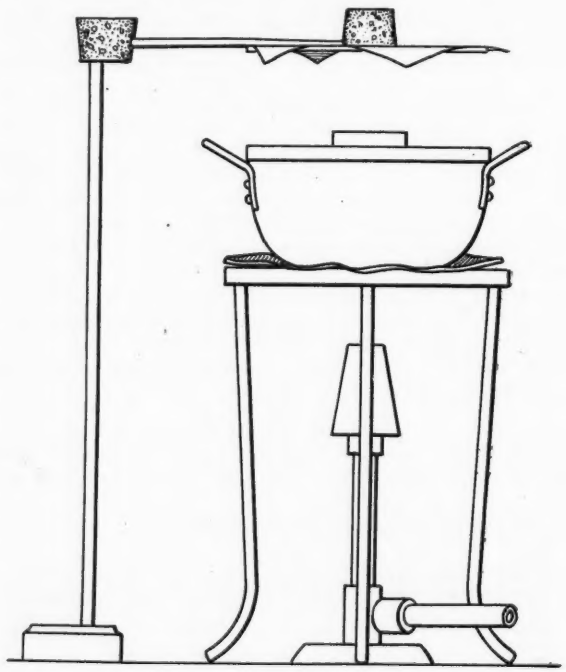


FIG. 3. USE OF PLATINUM BASIN AND WATER BATH IN TEST FOR TOTAL SOLIDS

After the filtration, the filter paper is washed with cold distilled water, which is run through it in the same direction as the water which has been filtered, then dried so far as possible by suction in the funnel and finally removed carefully and placed in the drying tube where a final heating is given it at 230 deg., the drying being continued until the weight is constant. The gain in weight expressed in grams, multiplied by 500, gives the number of parts of suspended matter in 100,000 parts of water.

If the dried suspended matter is red, it is an indication of iron oxide, and if it is of a gray slate color the indication is of clay.

Determination of Total Solids.

Unfiltered water well shaken up is used, 250 cu. centimeters of water being measured out. This is to be evaporated to dryness by means of a water bath which is done as follows: The water bath is a basin

containing water which is heated to the boiling point and the steam heat evaporates the water in the platinum dish. The platinum evaporating dish must not be allowed to touch the copper ring of the water bath but is supported by filter paper folded and placed between the basin and the edge of the ring so that a space is left for the escape of steam from the water in the bath.

Before weighing the platinum dish it should be thoroughly cleaned and heated for 5 minutes in an oven after which about 40 cu. centimeters of the water already measured out is poured carefully into the basin which has been placed in position on the water bath. Above the basin should be supported a triangle of glass or bamboo having on it a glazed paper which is held in place by a large cork to prevent any dirt or dust settling into the basin. The platinum basin should be sufficiently large so that the water does not come within ¼ in. of the top, as solutions of salt sometimes creep up and over the sides when being evaporated. The heat should be regulated so that the water bath boils steadily but not violently.

As evaporation proceeds, the rest of the 250 cu. centimeters of water is added and finally the measuring flask is rinsed out with distilled water and the

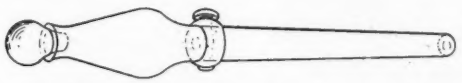


FIG. 4. SEPARATING FUNNEL USED IN TEST FOR OILS AND FATS

washings put into the basin to make sure that all solid matter carried with the measured portion is saved. Evaporation over the water bath is carried on until the residue in the bottom is apparently quite dry. The basin is then removed, the bottom carefully cleaned and wiped dry, any deposit being taken off by the use of hydrochloric acid with a wet towel; the basin with its contents is dried 3 hr. at 300 deg. F. in the drying oven. When cooling down, the basin should be placed in a closed dish containing a layer of calcium chloride, as otherwise the dry salts will absorb some moisture. When thoroughly cooled, the basin should be weighed and the increase in weight noted. This increase in grams multiplied by 400 will give the number of parts of solid matter per 100,000 parts of water.

Tests for Oil.

Where condensed steam is used for feeding the boiler it is best to test occasionally to find out whether any oil is being carried over. The water for this test should be cooled and then 250 cu. centimeters should be shaken vigorously in a separating funnel with 1-5 its volume of either petrol or ether. The funnel is then allowed to stand for a quarter of an hour upright and the water drawn off by the separating cock at the bottom. The petrol or ether solution which floats on the water and which would take up all the oil in the water is then run into a porcelain dish and evaporated over a water bath, no flame being kept under the hot water, as the vapor of petrol and ether is inflammable. No open flame must be allowed in the room where this operation is carried on. The solution will evaporate quickly, leaving any oil or fatty matter in the bottom of the basin. It is usually not of importance to determine the exact amount of oil in the water, as any amount which can be detected will be undesirable.

In all testing, the greatest care should be taken to get accurate weights and to see that the different operations are so performed that no errors will creep in. The quantities of water are small, the amounts of solid matter are minute and a slight degree of carelessness will largely change the results.

It is best at first, when practicing on the analysis of water, to take samples which have already been analyzed and see how closely the results of the former analysis can be checked. Tests for special impurities are made as follows:

For carbonic acid put into a test tube ¾ in. of the water and add an equal amount of lime water. If carbonic acid be present, the water will become milky, the milkiness disappearing on adding a little hydrochloric acid.

To test for lead, add to the water in a test tube a little dilute sulphuric acid and a white precipitate will be thrown down if lead is present.

Copper is indicated by a blue tinge upon the addition of ammonia water.

Iron is indicated by a blue color when a drop of ferrocyanide is added to the water in the test tube.

In these tests care should be taken to have the test tube always clean and it should be thoroughly rinsed out with distilled water after each test before going on to the next one.

Sulphate of lime is indicated by the formation of a white precipitate when a little chloride of barium is added to 1.5 in. of water in the test tube. This precipitate will not redissolve when a little nitric acid is added.

To test for magnesia put water into the test tube to 1-3 its depth and bring to a boil, then adding a little carbonate of ammonia and a trifle of phosphate of soda. Magnesia, if present, will come down as a white precipitate but may take a little time to do it, so that the tube should be set aside for a few minutes to settle.

Tests made by one who is not an expert will never serve as the basis on which to prescribe a treatment for the feed water but will give an indication as to whether the impurities contained in the water are such as to call for treatment or not.

COMPREHENSIVE INVESTIGATION of the properties of concrete and reinforced concrete is under way at the structural materials laboratories of the U. S. Geological Survey, St. Louis. This investigation includes tests of the strength of concrete beams and columns, the comparative value of gravel, granite, limestone and cinders for making concrete, the effect of age on the strength of concrete, and other points of interest to builders. The results of tests so far completed show that both tensile and compressive strength increase with age with the exception of limestone concrete, which shows an apparent decrease with age. In almost every case concrete mixed of rather dry consistency is strongest, but the difference is not great and practical considerations warrant the use of a wet mixture in order to get good tamping and smooth finish. As to the use of different materials for making concrete, it seems that the condition of the material has more to do with the strength of the concrete than the kind of material, and careful inspection must be made of each lot used.

"DO NOT WAIT for opportunities. Improve yourself constantly, and you will have all the opportunities that you can use. Make yourself a power in your own world and you will soon be wanted in a larger world."

METHODS OF PURIFYING FEED WATER

REMOVING SUSPENDED MATTER.

It is important that the floating matter be taken out, as it not only increases the amount of scale to be removed, and the labor of removing it, but is one of the greatest factors in causing foaming.

The methods employed for the removal of suspended matter from boiler feed water may be classified under 2 general heads: removal before entering the boiler and removal after the water is in the boiler.

It is generally conceded that the proper way to keep a boiler clean is by keeping all impurities out, though under circumstances where the feed water contains only a small percentage of impurities the necessary expense of adding and maintaining a complete system for treating feed water prior to its being fed to the boiler is hardly justifiable.

To remove suspended matter only from the water as it comes from lakes, rivers, ponds and the like before it enters the boiler three processes are in general use which may be employed singly or combined as the case demands.

Where the water carries such matter as is common to lumbering streams, chips, sawdust, sticks, grass, etc., a strainer placed in the suction pipe to the pump does very efficient work.

Water coming from shallow running streams is apt to contain clay, sand, small shells and other sediment that will readily settle if allowed to become quiet, for which purpose large settling tanks are frequently provided where the sediment may be drawn off at the bottom and the clear water taken from the top.

Rivers frequently contain the discharge of sewers and very fine particles of sand and other solid particles of material that will go through the finest practicable strainers and float in still water, in which cases filters are used to great advantage. Filter beds are composed of crushed quartz, charcoal, excelsior, burlap or any other material which will pack closely but still remain porous and present a rough surface to which particles of solid matter readily adhere. The beds should be provided with a convenient means for washing and cleaning them out at frequent intervals as a polluted filter bed is worse than none.

The filtering process is often aided by the use of a coagulant, such as alum in solution, which gathers the small particles of animal matter together into adhesive masses that will not pass through the pores of the filter bed.

Removal of Suspended Matter After Entering Boiler.

When suspended matter is admitted into a boiler it either floats or sinks to the bottom.

To remove floating particles, boilers are frequently equipped with some sort of skimming device which automatically removes the surface water with its impurities to a filter or purifier where the solid particles are retained, and the water thus clarified is returned to the boiler. These purifiers are provided with an easy method for removing sediment and relieve the boiler of much injurious as well as dangerous matter.

Suspended matter which settles to the bottom of the boiler in soft form is removed through the blow-off valve with some style of which every modern boiler is equipped. This subject will be taken up more fully under the head of Blowing Down.

THE BLACKBURN-SMITH FEED WATER FILTER AND GREASE EXTRACTOR

James Beggs & Co., New York City

We illustrate the Blackburn-Smith feed water filter and grease extractor, a device which is installed in the feed line and subjects all entering water to double filtration through separated Terry cloths. If an open heater is used, this filter is placed between the pump and the boiler, but if the heater is of the closed type, the filter should be installed between the pump and the heater in order that the suspended particles will be caught before they can settle on and reduce the efficiency of the heater surface.

The filter, so installed, is very effective in removing mechanically suspended particles from the water supply, for removing particles of oil, grease and dirt from the

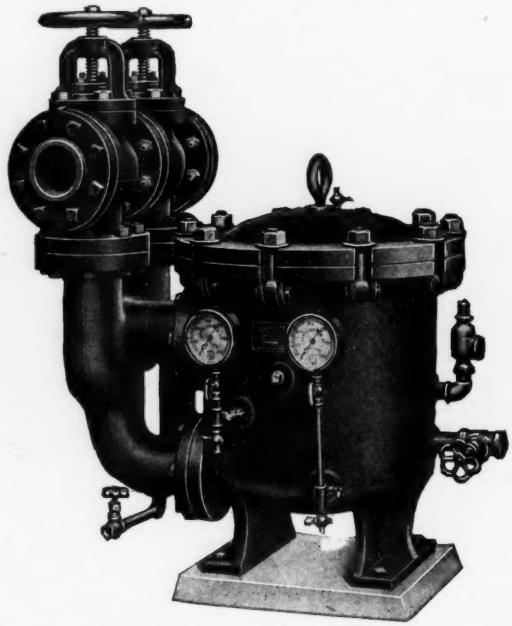


FIG. 1. THE BLACKBURN-SMITH FEED WATER FILTER

lines, and anywhere that the condensed exhaust returns from steam heating systems, condensers, drying coils, etc., are fed into the boiler again. By removing the scale-forming matter the filter makes repair bills fewer, reduces the coal bills, and effects a marked saving in water bills due to the use of condensation.

The Terry cloth can be cleaned and used over and over. Where muddy water is to be filtered, or where oil or grease are present in large quantities two or more filters are run in parallel. Each filter can then be thrown into service or cut out at will, and any filter can be cleaned while the plant is running.

Referring to the cross-section, water from the feed pump enters the inlet, passes into the upper or filtering chamber through the filtering cartridges, into the pump chamber, and thence from the outlet to the closed heater or boiler.

The water passes through the cartridges with little friction, but in the course of time, as the foreign matter accumulates on the filtering material, some resistance will result. This resistance is shown by the reading of pres-

sure gauges connected to the filtering and outlet chambers. When the difference of pressure as shown by the gauges increases to 20 lb. per sq. in. the filter should be cleaned. A water relief valve automatically prevents the building of excessive pressure in the pump discharge line.

An occasional opening of the air cock located near the center of the cover will prevent air in the filter from being carried into the boilers.

The valve chamber is made right or left hand as desired so that the filter may be set on either side of the

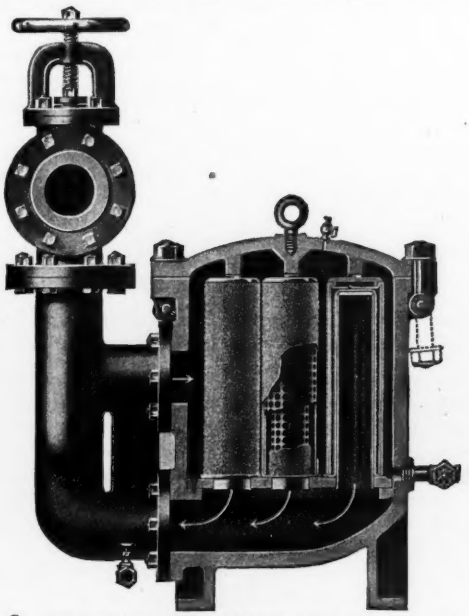


FIG. 2. THE BLACKBURN-SMITH FEED WATER FILTER, SECTIONAL VIEW

line. Both the main valves are in a straight line with the feed pipe. The filter is put into operation by turning the hand wheels on both inlet and outlet valves to their upper limits. When these two wheels are turned to their lower limits the feed water goes straight past the filter. The by-pass and main valves are wholly within the feed line and the filter body and valve chamber may be disconnected close to the valves. It is thus possible to remove almost the whole filter without shutting down the plant.

The cartridge construction compels double filtration through 2 separate and independent filtering surfaces. The number of cartridges in each filter varies with the size of the unit. Each cartridge consists of 2 concentric cylinders of heavy perforated brass tubing, covered with linen Terry. The lower end of the inner cylinder is expanded into the partition which separates the filtering and outlet chambers, and the upper end is covered by a perforated brass cap. The filtering media conform to the shape of the cartridges, the closed end being drawn down to a nice fit over the inner cylinder, reversed over the outer cylinder, and the other end tucked in and clamped by the brass cap.

Heavy impurities which may at times cling to the walls of the filtering chamber or settle to the bottom may be blown out by opening the sludge valve and admitting live steam through a tap for that purpose.

The body and valve chamber of the filter are ordinarily made of cast iron, and each filter is tested to a hydrostatic pressure of 300 pounds to the square inch.

INTERNATIONAL FILTER

International Filter Co., Chicago

The filter body consists of 2 shells, which are hinged together and clamped around the edge by means of hand bolts. The inlet is in the lower shell, the outlet in the upper, and the entire filter body is surrounded by a rim or gutter, which catches any overflow on opening the filter.

The filter is made in 2 styles, 1 of high grade brass, block-tinned throughout, the other of iron heavily galvanized with brass fittings and trimmings. The pedestal, made of iron, is detachable and entirely independent of the filter body.

The medium used in the International filter is in the form of disks made of specially compressed pure cotton fiber absolutely free from chemicals. These filter disks present a perfectly uniform filtering surface and will remove all suspended matter from the water without affecting the soluble constituents in any way. No alum or chemicals are used in connection with this filter.

The filtering is accomplished by means of the filter disks, which are placed in the filter and securely

INTERNATIONAL FILTER

locked all around the edge between the 2 filter shells, so that, as the disks extend to the outer edge of the body, when in place between the locking margins of the filter shells, they form the equivalent of a gasket, doing away with the use of a separate rubber gasket or packing ring.

KEYSTONE PRESSURE FILTER SYSTEM

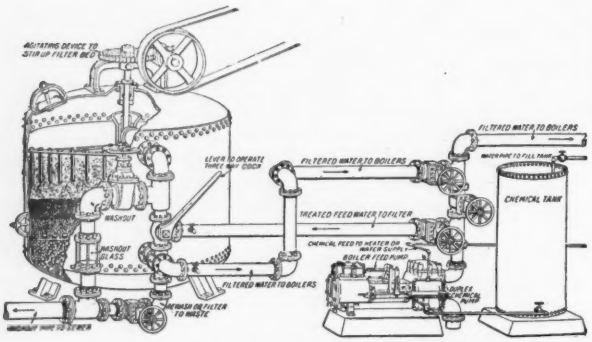
Keystone Chemical Mfg. Co., Philadelphia, Pa.

This system of water purification provides for the removal in 1 operation of both suspended vegetable or animal impurities, and the more dangerous dissolved mineral scale forming substances such as sulphates and carbonates of lime and magnesia.

A small chemical pump attached to the boiler feed pump introduces into the feed water a correctly proportioned amount of the necessary chemical, as determined by analysis of the water, required to precipitate in the form of soft flocculent phosphates all harmful dissolved impurities.

In this form they are easily and thoroughly filtered out, together with all suspended impurities, as the water passes through the deep bed of crushed and especially selected quartz contained in the filter proper, and the water enters the boiler free from all impurities or chemicals.

The filter is simple in construction and operation; essentially it is a cylindrical steel shell standing upright


AGITATING DEVICE TO STIR UP FILTER BED
LEVER TO OPERATE THREE WAY COCK
WASHOUT
GAUGE GLASS
FILTERED WATER TO BOILERS
TREATED FEED WATER TO FILTER
CHEMICAL FEED TO HEATER OR WATER SUPPLY TO BOILER FEED PUMP
BOILER FEED PUMP
FILTERED WATER TO BOILERS
BACKWASH OR FILTER TO WASTE
FILTERED WATER TO BOILERS
WATER PIPE TO FILL TANK
CHEMICAL TANK

KEYSTONE PRESSURE FILTER SYSTEM

on strong cast iron legs, and containing a deep bed of quartz. At the top is a steel agitator operated by power or hand, by means of which the filtering bed may be thoroughly loosened up when desired.

The strainers are of non-corroding bronze with solid top, having openings in the sides, so that the weight of

LIBERTY TWIN STRAINER

the quartz above may be easily sustained. There are a great many of these, arranged uniformly around the bottom, so that every part of the filtering bed must perform an equal amount of work. The outlet from all the strainers is through one central drain to the boiler connections.

A drain cock is provided for draining off the water from that part of the filter below the strainers. For washing, pipe connections enable the current to be reversed; and all accumulated impurities may be washed into the sewer.

THE LIBERTY TWIN STRAINER

Liberty Mfg. Co., Pittsburg, Pa.

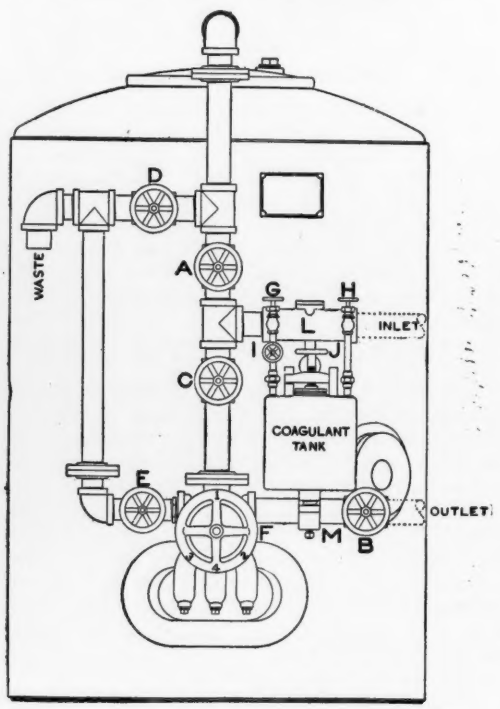
This appliance for the removal of suspended matter from feed waters is composed of two chambers, each containing a basket shaped strainer, removably secured to the side of the casting, forming perforated pockets, which catch and retain the dirt in the water. By an arrangement of valves the flow of the water is caused to pass through one basket while the other is being treated or replaced without interrupting the flow. Access to the basket for cleaning is had through doors in the front of the casting.

THE NEW YORK SECTIONAL WASH PRESSURE FILTER

The New York Continental Jewell Filtration Co., New York City

In this apparatus for the removal of suspended matter from feed water the supply enters the tank at the top and passes through the bed, which is composed of sand, into the strainer system, which is embedded in concrete in the bottom of the filter, and then through the outlet.

The essential of this type of filter is the method of washing, by which the water, under pressure, enters

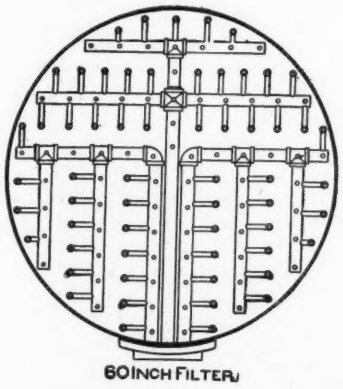


THE NEW YORK SECTIONAL WASH PRESSURE FILTER

the filter at the bottom, passes up and out at the top; the full force of this reverse current used in washing is directed against but 1-3 of the bed at a time for about 5 min.; then it is shut off and the second third of the bed

is scoured in the same manner; lastly, the remaining third is washed.

By this system of washing the filter bed, a thorough scouring of particles is accomplished, as the entire supply of water and the pressure is directed against the third of the bed being washed, and no partitions are necessary to divide the bed, as the current is forced up nearly in a



STRAINER BED OF SECTIONAL WASH PRESSURE FILTER

straight line. No power or machinery for stirring the bed is required when cleansing filters by sectional washing.

For large capacities this filter is made with the tanks in a horizontal position.

This concern also manufactures the Continental Double-Cylinder Filter, which provides double filtration through sand and bone-charcoal.

ROSS FEED WATER FILTERS

Ross Valve Co., Troy, New York

Reference to the sectional cut shown herewith, will readily explain the operation of the filter. The valves of the filter being as shown in position for regular operation and filtering, the water enters the right hand pipe at the top and passes down into the large chamber below. The central portion of this chamber is occupied by the filter, which extends horizontally the entire length, the filtering material employed being linen Terry or Turkish toweling. The skeleton of the filter as shown in Fig. 2 consists of light circular bronze sections of open lattice work, held together by long bolts extending through the whole. The toweling, which is in the shape of a bag and much longer than the skeleton, is drawn over the inner section between the sections by means of strings wound around it; the filtering surface thus provided is from 150 to 1,000 times the area of the feeding pipe. The water then passes slowly through the filtering material into the interior of the skeleton, out at the left hand end and thence to the boiler.

The oil or other matter separated from the water accumulates on the outside of the filtering material and in time gives it a very appreciable resistance to the free flow of water, which will be indicated by the difference in the reading of the 2 pressure gauges shown; when this difference reaches 2 or 3 lb. the filter may be cleaned by reverse washing or by changing the filter. It will be noticed that valve A has a face on both upper and lower sides that sets upon both the upper and lower bushings. If the valve is screwed down, the feed water passes to the boiler without passing through the filter. If B is closed and the draft cock at the bottom opened, the head may be taken off and the clogged filter removed. This arrangement of valves also enables the operator to wash the filter by reversing the water through the filter when it is in place.

WRIGHT FILTER.

Wright Mfg. Co., Detroit, Mich.

This filter is used where the source of boiler feed is from rivers, ponds, lakes, etc., a condition subject-

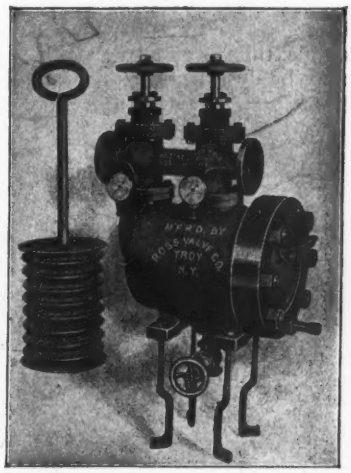


FIG. 1. ROSS FEED-WATER FILTER

ing the boilers to impurities, resulting in scale, etc. Installed in pipe lines leading to return steam traps, its use eliminates the possibility of foreign matter obstructing the valves.

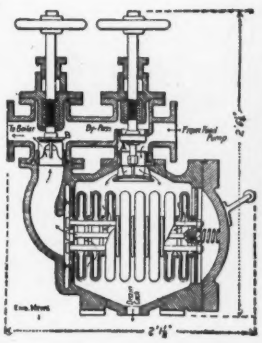
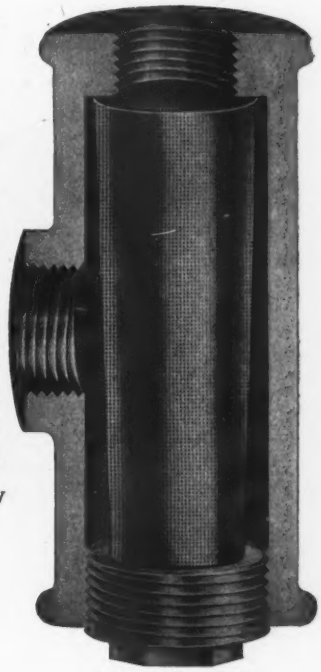


FIG. 2. SECTIONAL VIEW ROSS FEED-WATER FILTER.



WRIGHT FILTER

The water entering at the top is forced through the fine meshes of the brass filtering tube, the area of which is much larger than the inlet, leaving on the in-

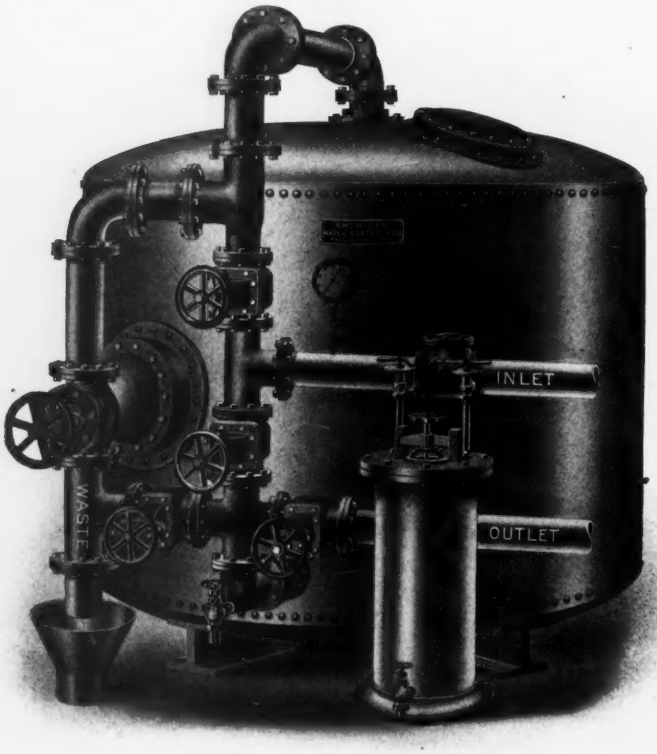
ner side all suspended matter, and passes out at the opening shown to the left.

A simple blow-off valve screwed into the opening in the plug and opened occasionally, serves to keep the filter free from accumulated matter. The filter tube is easily removed by unscrewing the plug to which the tube is attached.

VERTICAL TYPE STEEL TANK PRESSURE FILTER.

American Water Softener Co., Philadelphia.

The filter tank is made of the best grade of tank steel of ample thickness to sustain the pressure for which it may be designed, and all seams substantially



VERTICAL TYPE STEEL TANK PRESSURE FILTER

riveted and well calked, to sustain internal pressure from 100 to 200 lb. per square inch. The strainer system consists of a heavy cast-iron manifold or main collector elliptical in form and having flanged ends to be bolted together with a light rubber gasket at each joint. The strainers or sand valves are of heavy brass and have no sawed slots and are devoid of wire gauze or thin perforated metal. The bottom of the filter below the strainer system is to be filled with concrete so as to make a level floor with only the strainer heads exposed above its surface. The filtering material consists of carefully screened, washed and graded silicate sand and gravel.

In filtering, water enters the top of the filter and passes downward through the bed of filtering material. The current is reversed in washing, water entering the bottom and passing upward through the filtering material which is thoroughly and completely broken up, agitated and scoured, all dirt and impurities intercepted since the last washing operation being carried to the drain or sewer through the waste pipe. The washing operation, which is repeated about once every 24 hrs., leaves the filter bed clean. The filtering material is gradually worn away by attrition during the washing process and requires replenishing once in from 5 to 6 yr.

In clarifying and purifying waters these filters without a coagulant would remove only those suspended matters larger than the voids between the sand grains. It is, therefore, necessary in treating muddy or impure waters to use a coagulant, alum, and each filter is supplied with a feed tank which automatically adds alum water drop by drop to the main volume of water on its way to the filter through the inlet pipe.

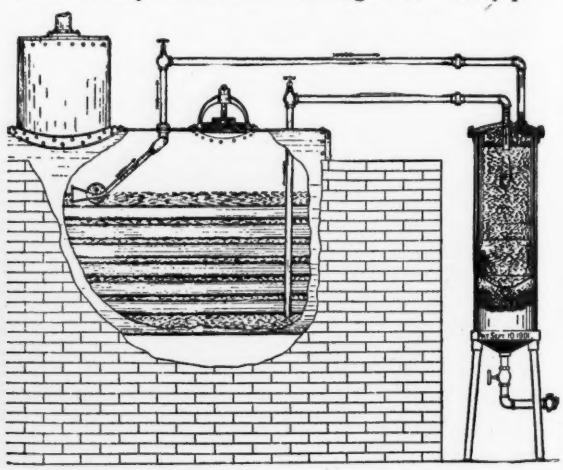


FIG. 1. BUCKEYE AUTOMATIC BOILER CLEANER

FIG. 2. BUCKEYE FLOATING SKIMMER

Alum gathers into large flaky and gelatinous masses, the smallest suspended particles, and these coagulated masses being larger than the voids between the sand grains are deposited in the filtering bed. The alum is precipitated and retained within the filter as the insoluble hydrate of aluminum.

THE BUCKEYE FLOATING SKIMMER

The Buckeye Boiler Skimmer Co., Toledo, O.

The Buckeye automatic boiler cleaner has a floating skimmer consisting of a wide-mouthed copper funnel, carried by two high pressure copper floats, and connected to a cold drawn copper tubular arm, through which the impurities pass from the surface of the water in the boiler through a system of piping to a settling chamber, or precipitator.

By this floating arrangement the skimming funnel is always kept at the same depth in the water regardless of the water level. With this cleaner attached to the boiler,

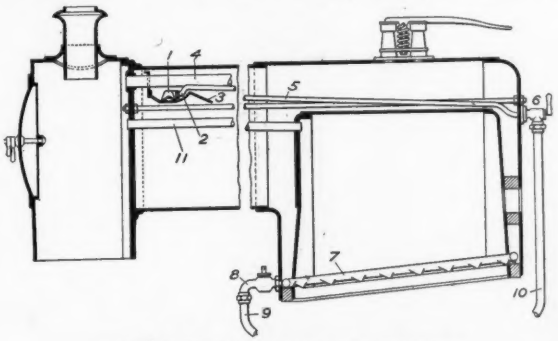
a continuous circulation is kept up through the funnel, tubular arm, knuckle joint and precipitating tank. The scum and impurities being taken from the surface of the water in the boiler are deposited in the precipitator, which precipitator contains a system of baffle plates causing the impurities to settle to the bottom, and forcing the clear water back into the boiler, at a slightly reduced temperature.

The impurities in the precipitator are blown out as often as necessary, by opening the valve at the bottom, which requires but a few seconds time. This blowing off, under ordinary conditions, is necessary only every two hours, unless conditions are extremely bad.

CLARK MECHANICAL BOILER CLEANER

A. C. Clark & Co., Grand Crossing, Chicago, Ill.

The patent mechanical boiler cleaner consists essentially of 3 parts, 1 being situated at the forward upper end of the boiler barrel, 1 set within the water legs surrounding the fire box and resting on the foundation ring and the third along the bottom of the boiler barrel, the function of the first being to intercept the impurities brought to the surface in the process of ebullition and carried forward by the natural circulation of the water, while the 1 around the water leg discharges the deposits precipitated around the fire box, where the greatest amount of accumula-



CLARK MECHANICAL BOILER CLEANER

tion is found. The third takes care of all deposit precipitated along the entire length of the boiler barrel.

The usual arrangement of 1 form of this apparatus is shown in the illustration, from which it will be seen that the front portion of the cleaner consists of a skimmer trough, 2, in the space between the boiler and the tubes, and the dry pipe extending the whole width of the boiler barrel to which it is suitably attached.

A deflector plate or scoop, 3, is provided so as to collect the forward moving solids to a sufficient depth below the water surface to insure their reaching the trough. Thus all surface impurities and scum forming matters are directed into the skimmer trough or basin, which, as shown in the drawing, forms a receptacle of some 7 or 8 gal. capacity in which precipitation takes place and from which the sediment may be completely blown off, with a minimum waste of water, as frequently as desired, by means of the draw-off head within it, shown at 1, and the scum cock, 6.

The draw-off head consists of a gun metal casting in the form of a horizontal passage or pipe, having ports or suckers in its underside communicating with the above pipe or passage and being inclined relatively to it, so as to offer the least possible obstruction to the scum drawn or sucked in.

Another portion of the cleaner is situated at the bottom of the water legs, surrounding the fire box, as shown at 7. The construction and action in it closely resemble the front end fitting already described, with the exception that in this case, the skimmer trough is dispensed with as being unnecessary, the water spaces in which the draw-off heads are placed providing the requisite collecting chamber for such solids as have not been removed by the forward draw-off head and scum cock.

These draw-off heads are 2 or more in number and are arranged so as to practically encircle the fire box. Each has its own blowoff cock, 8, which may be brought out at the side, front, or back of the fire box, as desired.

THE SIMS IMPROVED FILTER BOILER CLEANER

The Sims Co., Erie, Pa.

In this cleaner 4 funnels are provided of such size as to cover a large surface of water and are suspended near the rear of the boiler, with openings towards the front, rear and sides, with the average water line in the center of the skimmer. Impurities gather from all directions to this point, but coming chiefly from the forward part of the boiler float into the skimmer and are drawn up by circulation, the water being returned from the filtering tank in the boiler through a pipe which is exposed to the heat in the rear arch. Water from the skimmer is taken to a precipitator, through which it flows slowly,

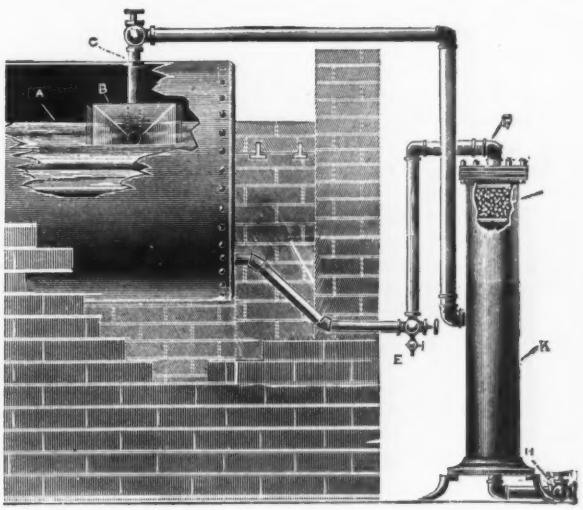


FIG. 1. SIMS IMPROVED FILTER BOILER CLEANER

allowing the impurities to settle out. In the upper part of the settling tank is a coke filter through which the water flows on its return to the boiler; the impurities removed from the water are blown off at intervals.

A MIXTURE OF THE FOLLOWING ingredients forms an acid-resisting cement for tanks, floors, etc.: Silicate of soda, 6 parts (water-glass); glycerin, 1 part; red lead, 3.5 parts; fine cinders, 10 parts.

NEVER MISS A CHANCE to compare the steam gage with the safety valve when the latter is blowing. In case of difference find out which is wrong and rectify it.

REMOVAL OF MINERAL SALTS

Undesirable mineral salts are removed from boiler water in 1 of 3 ways: by water softening, by heating and settling or by the use of boiler compounds.

Water Softening.

What is known as hard water is that which will cause a clear soap solution to become milky in color. The impurities which cause this quality of water are the sulphates and carbonates of calcium and magnesium and are the ones which give the most general trouble to boilers.

Water softening is carried on under 1 of 2 different conditions, i. e., hot or cold, which differ in chemical treatment. The cold process is again divided into 2 classes, continuous and intermittent, which differ only in mechanical means for handling the water and chemicals.

The cold process is most generally employed where large quantities of water are required and no convenient means for heating are available. In this process the cold raw water is treated with chemicals in just the proper proportions to precipitate all the impurities held in solution. To remove permanent hardness a predetermined amount of soda-ash solution is fed into the water either at regular intervals or continuously by some proportioning device. By the use of this chemical the sulphates are turned into carbonates which are precipitated and sodium sulphate is held in solution. In case, however, the water contains an acid, such as carbonic acid, which is most generally the case, the carbonates remain in solution and the water is temporarily hard.

To remove these objectionable impurities a solution of lime is added in the proper proportion to neutralize the acid present and the calcium and magnesium carbonates are then precipitated in the form of a soft sludge which is allowed to settle in a large tank and removed by blowing-off, or in cases where smaller tanks are used these precipitates are prevented from entering the boiler by means of a filter. The sodium sulphate which is held in solution as a result of this process is deposited in the boiler upon heating as a harmless sludge which is removed through the blowoff.

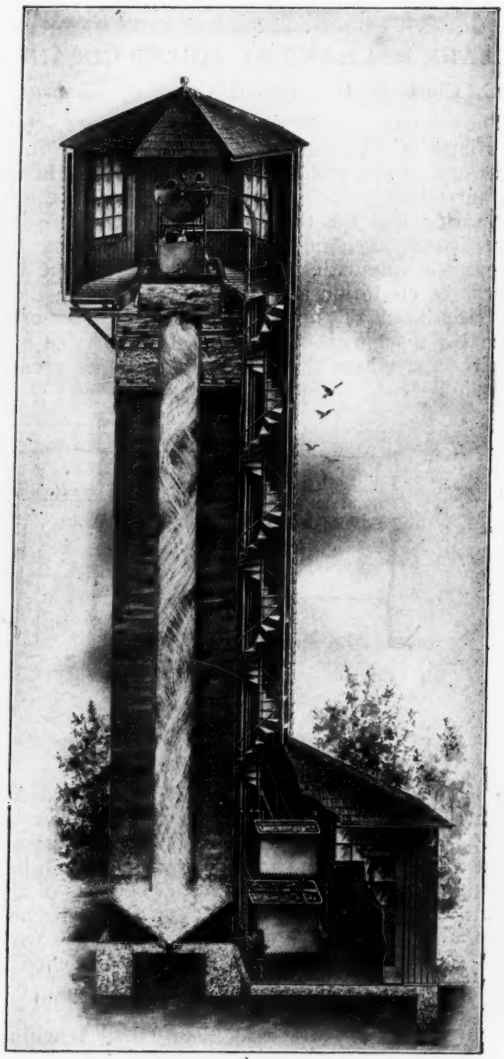
In the hot process for purifying water, soda-ash is used just as in the cold process, but to remove the carbonates the water is heated by exhaust steam to the boiling temperature, when the precipitates are allowed to settle and the water is drawn to the boiler through a filter.

THE AMERICAN WATER SOFTENER.

American Water Softener Co., Philadelphia, Pa.

A sectional view of the American system is shown herewith. Crude water, supplied at the ground floor, works a small motor without waste of the water, then rises to the measuring and mixing mechanism at the top of the settling tank where a certain percentage of reagent, as determined by chemical analysis in the laboratory of the company, is automatically added to the water. This is thoroughly mixed with the water by a whirling motion given to it as it passes through the downtake pipe in the center. During this time the reagent or chemical precipitates and coagulates scale-forming solids and these solids sink to the bottom of the tank, partly during the fall through the downtake pipe and partly during the slow rise of the water through the large uptake outside. Clear, purified water then flows by gravity to the storage tank.

Preparing and handling of the chemical solution for softening is attended to entirely at the ground level. The mixture or solution is then pumped to the chemical tank at the top of the tower, the power for



AMERICAN WATER SOFTENER SYSTEM

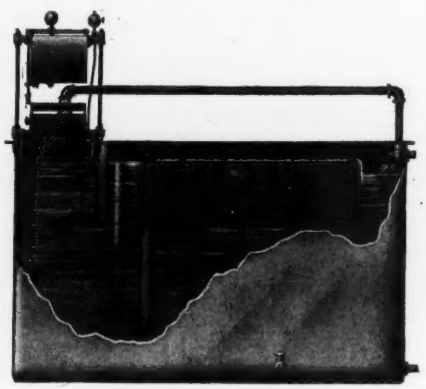
running this mixing and pumping mechanism being furnished by a water motor. The water driving this motor, after leaving it, passes to the top of the tank and into the oscillating receiver. An effective water pressure of 3 lb. is sufficient to run the motor. Solution tanks are made large enough to contain from 12 to 24 hrs.' supply so that a man needs to give attention to this plant for but 15 to 30 min. a day, after which the machine operates automatically as long as any softening solution remains.

At the top of the tank is a chemical reservoir into

which the softening solution is pumped from ground level through a small upper pipe and from which any surplus returns through a small lower pipe. The crude water is pumped through a large pipe into an oscillating receiver which tips first one way and then the other by the weight of the water in the filled

TIPPER AND SOLUTION RESERVOIR

chamber. At each tip the valve in the semicircular solution reservoir is lifted allowing a definite amount of the solution to drop into the oscillating chamber. As the oscillating chamber always takes the same amount of water and the head on the solution valve is constant, the right proportions are always maintained between solution and crude water. The lift of the solution valve is quickly and easily adjustable for any variation in quality of crude water. The chemicals



AMERICAN SOFTENER IN BOILER ROOM

in the solution reservoir are constantly stirred by a rod and rocker arm device, and a paddle is fixed to the under side of the oscillating receiver to stir the water and chemicals together thoroughly while passing to the downtake.

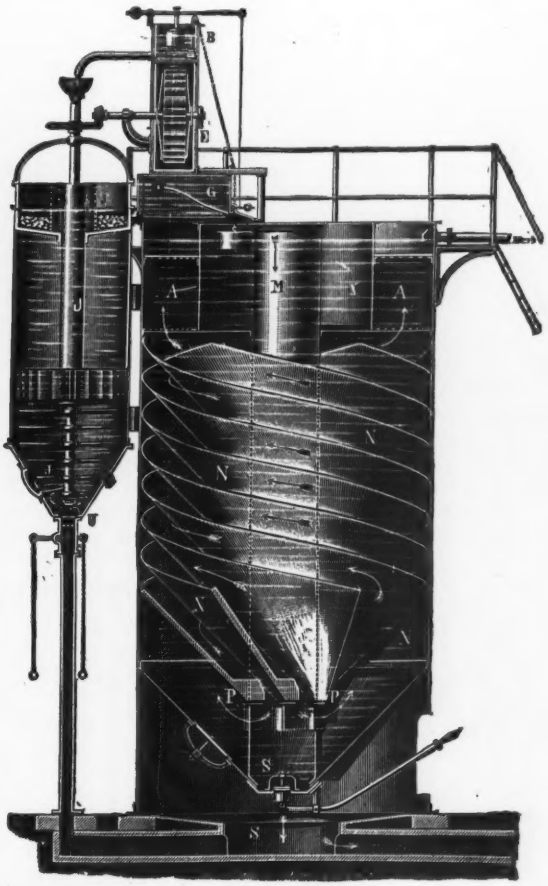
These water softening systems are built for any capacity by modifying the design of the settling tank. Fig. 3 shows the smaller type, which is their standard for boiler room installation.

EUREKA WATER SOFTENING APPARATUS

Dodge Mfg. Co., Mishawaka, Ind.

The Eureka Apparatus consists essentially of two portions, the smaller a lime saturating tank, and the larger a decanting tank, for precipitation of the scale-forming constituents after being acted upon by the lime solution and reagents.

The water to be treated enters the top tank B and is divided under proper automatic control for delivery.



SECTIONAL VIEW SHOWING CONSTRUCTION OF THE EUREKA AUTOMATIC WATER SOFTENING APPARATUS

a small portion to the saturator J, the greater portion to the decanting tank. On its way to the decanting tank the water passes over a wheel E whose rotation actuates stirrer arms in the saturator.

The saturator J, with its stirring apparatus, provides a continuous supply of saturated lime solution, which is fed with other reagents, in proper proportions, under automatic control, from a small tank G into the central tank M of the decanter. Here the reaction takes place, the water passing downward and returning upward in the main body of the large tank, passing spirally among the slant settling plates N. On these spiral surfaces the scale-forming matters and other impurities are deposited in flakes which gravitate freely to the conical bottom of the main tank, whence they may be passed off into the sewer by occasional opening of the valve S. Any sediment forming at the bottom of the lime saturator tank may similarly be blown off through the valve U.

The water itself, continuing upward, passes through filtering material A into an annular space, whence it is drawn off as wanted, thoroughly softened and purified.

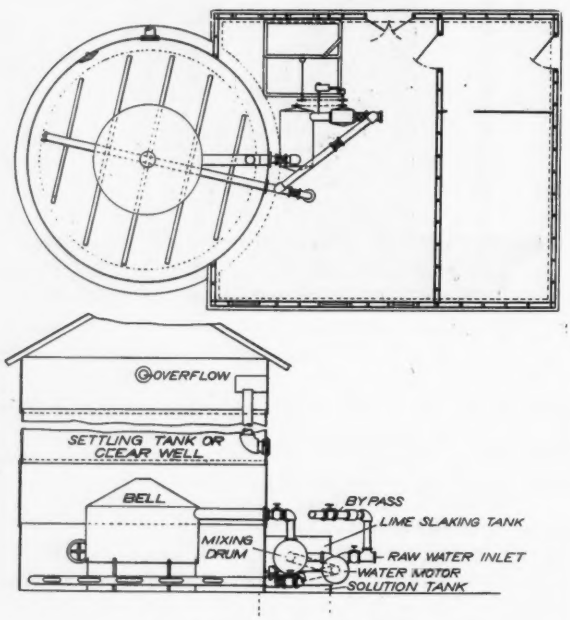
The whole operation is simple and entirely automatic, the apparatus holding itself always ready to deliver soft water in any quantity within its rated capacity, either steadily or intermittently. The water is treated cold by means of reagents which may be bought in any market at trifling cost. All the attention required in its operation is to renew daily the lime and other reagents in prescribed proportions and to flush out the accumulated slush by opening the valves S and U. All of this requires only a few minutes of time on the part of some regular employe of the power department.

The apparatus cannot become clogged; there are no complicated parts; the construction is solid and substantial; and in no respect is more than ordinary care required in the operation. The apparatus will precipitate and eliminate from the hardest water all scale-forming matter and impurities, producing pure and soft water for boiler feeding and other industrial purposes.

HOLMEN WATER SOFTENER.

Herewith is shown a 30,000-gal. per hour water softener designed by A. R. Holmen, chief draftsman of the motive power department, and built by the Southwest System of the Pennsylvania lines west of Pittsburgh at their shops in Indianapolis, Ind.

The softener consists of a settling tank or clear well, a mixing drum, a solution tank with lime slaking tank



HOLMEN WATER SOFTENER

above, an adjustable solution pump, a water motor and necessary piping. To the water motor shaft is attached, by chains and sprockets, stirring apparatus mounted in the mixing drum and solution tank, also by an adjustable crank arm, the solution pump.

When the valve at the raw water inlet is opened the water passes through the motor and sets it in rotation. Through the motor shaft the motion is transmitted to the stirring apparatus and solution pump. For each revolution of the motor the solution pump makes one stroke. The length of the stroke and the strength of the solution, which at Indianapolis contains lime and soda ash, are so adjusted that the necessary amount of chemicals, required for the proper softening, are pumped into the raw water, inside the mixing drum, where the water is agitated for about 1 minute before flowing through the pipe to the bell in the settling tank. Under the lower edge of the bell the water passes into the settling tank, where it rises to the top and flows to the storage tanks through the overflow pipe.

Thorough mixing of the water and chemicals, under pressure, hastens the chemical action so that it is completed before leaving the bell, also crowds together the precipitate in a more compact form, resulting in a quick and more complete clarification.

For removing the sludge a system of pipes is located in the bottom of the settling tank and connected to a waste discharge. The raw water inlet and sludge pipe are connected with a bypass pipe, having necessary valves, by which the raw water can be let directly into the settling tank, for stirring up the sludge, or when necessary to make any repairs to the machinery.

The softener is not supplied with filters, as it was thought, for reasons given above, that the settling of the precipitate would be complete, but pipe, shown to the right in the settling tank, and floor space in the building are provided, so that sand filters can be put in if so desired. The softener having all machinery on the ground, and being of few parts and simple design, requires little work for the operation and maintenance, and has given a most satisfactory result during the 15 months it has been in operation.

The average hardness of the raw water has been 45 deg., and after softening 8 to 9 deg.

KENNICOTT WATER SOFTENER, TYPE K

Kennicott Water Softener Co., Chicago

A calculated quantity of lime is put into the lime slaking tank, A, and slaked with sufficient water to make it thin enough to flow. Then the lime is allowed to flow through a valve into the chemical tank, B. A calculated quantity of soda is put into the chemical tank with the slaked lime and enough water added to fill it to a definite point.

The agitator, C, propelled by the water wheel, D, keeps the contents of the chemical tank mixed.

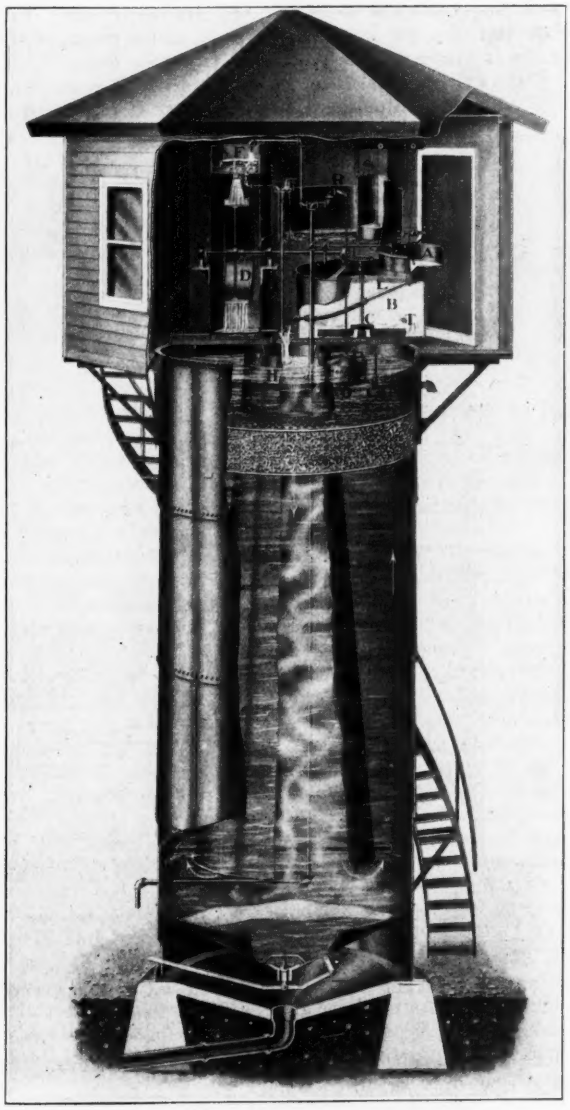
The water to be treated enters by way of the hard water inlet pipe, E, into the hard water box, F, where it is divided. The greater part of the water flows through an opening in the bottom of this box, over the water wheel and through the chute, G, into the top of the cone, H.

The lesser part of the water from the hard water box flows through a pipe into the dividing box, I, where it is divided by an apportioning slide, J, one part flowing into the regulating tank, K, and the other part into the top of the cone through a pipe. The apportioning slide may be set according to graduations on the side of the dividing box so that the regulating tank will fill in a definite number of hours, the machine running at full capacity.

The head of the lift pipe, L, in the chemical tank is connected by a chain to a float, M, in the reuglating tank. As the regulating tank very slowly fills with water from the dividing box the float rises, the head of the lift pipe lowers, and the contents of the chemical tank flow out

through the lift pipe into the top of the cone, where they are mixed with the water to be treated which comes in over the water wheel.

The purifying materials and the water to be purified, which enter the cone or down-take, are intimately mixed so that precipitation of the scale-forming matter at once takes place. The water, together with the precipitated lime and magnesia, travels slowly downward through the down-take, which is so sized and shaped as to cause a



TYPE "K" KENNICOTT WATER SOFTENER

constant decrease in the rate of flow, and in this manner the precipitate falls away from the water in the main settling tank, whence it is, at regular intervals, blown out into the sewer by means of a dump valve.

The remaining particles of precipitate, if any, have another opportunity to settle as the water, after passing downward through the cone turns and passes up in the space between the cone and the shell of the main tank, the rate of flow constantly decreasing.

As a final purification, the rising water moving at its slowest rate passes through a wood fibre filter near the top of the apparatus, shown in the illustration just below the mouth of the cone, whence it emerges soft, clear, and ready for use.

As the main tank always stands full of water, the clear, soft, treated water discharges from the overflow on the side of the main tank at a point above the filter as fast as the water to be treated enters the top of the cone.

When the regulating tank becomes full it is emptied, another charge of lime and soda is put into the chemical tank, and as the regulating tank again very slowly fills the charge of lime and soda flows out through the lift pipe.

The float, M, is equipped with an electrical contact device which, when the supply of softening materials is about exhausted, causes a bell to ring, thus notifying the man in charge of the apparatus that a fresh supply of softening reagents is required, and this bell continues to ring until the attendant goes to the softening plant and turns a switch.

When the consumption of treated water is less than the capacity of the machine, the overflow being closed by an automatic valve or other means, the water will rise in the top of the main tank to the little float, N, raise it until it closes the opening in the bottom of the float pot, O, and still rises until it reaches the top of the float pot, which will immediately fill, raising the shut-off float, P, which closes the balanced valve, R, in the hard water inlet pipe, E, so that no more water can enter the machine.

When the overflow on the side of the main tank is opened, the surface of the water lowers in the top of the main tank to the level of the overflow, allowing the little float, N, to drop sufficiently to free the opening in the bottom of the float pot, which allows the water in the float pot to run out. The shut-off float, P, drops down, opening the balanced valve, allowing the hard water again to enter and start the machine in full operation, which is the object of this arrangement of floats.

The machine is continuous and automatic in its operation, the flow of water furnishing all the power necessary for mixing the chemical reagents with the water and for operating the mechanism.

WATER DISTILLING APPARATUS.

Pure Water Co. of America, Philadelphia, Pa.

It may appear strange to the average engineer to propose to purify water for boiler use by distillation, but there are many grades of water, such as sea water and certain alkaline waters, with which no other process will serve.

The illustration shows an apparatus that will purify any water, and at a cost in some cases as low as 10 cents per 1,000 gal. It operates on the multiple effect principle, and automatically maintains any desired pressure and temperature difference between the different cells or effects, thus making possible any number of effects or duplications. The illustration is reproduced from a photograph of an apparatus with 10 effects which after rigid tests gave the following among its results: Distillate produced in 12 hrs., 39,765 lb.; steam drawn from primary boiler, 6,698 lb.; distilled water per pound of steam so drawn, 5,936 lb.; coal cost at $2 per ton, 14 cents per 1,000 gal. The efficiency shown can be doubled in larger stills.

To economize fuel the process must involve what is known as multiple effect, or the repeated use of the heat coming from the primary boiler in the initial steam.

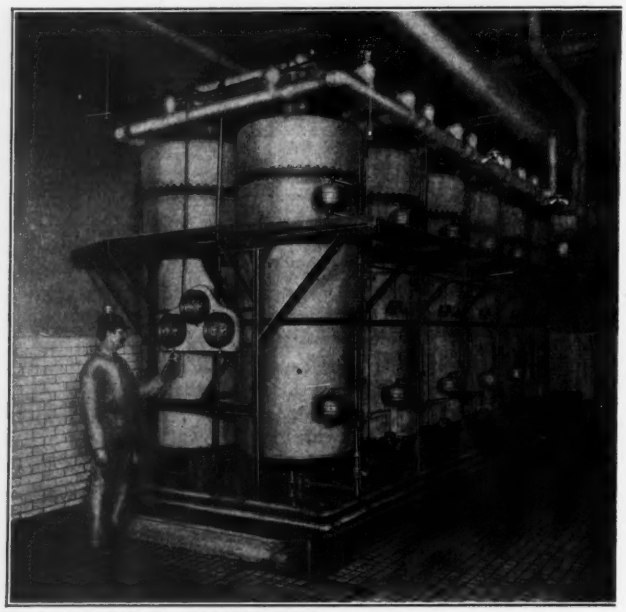
This must be so accomplished as to allow of an auto-

matic but infallible fixing of the temperature difference between the inner and outer surfaces of the condenser.

The heat lost by radiation from the outer surface of the apparatus must be as far as possible recouped from that in the escaping distillate, and such distillate issue from the apparatus at as near the temperature of the incoming raw water as possible. No condensing water is allowed to run to waste.

The cleansing of the apparatus is readily and inexpensively performed, and the operation of the whole is automatic and continuous.

The apparatus consists, essentially, of a steam generator of efficient type, a cooler or heat exchange, where the heat in the distillate is passed to the incoming raw water on its way to be purified, and a condenser, surrounded by a jacket of raw water maintained at a fixed difference of pressure below the enclosed condenser, which difference of temperature can be varied at will, and wherein the steam is condensed in such a manner that the gases contained in it are not absorbed by the distillate but are eliminated. Steam is thus formed in the jacket by the evaporation of the raw water therein, which in turn passes to a second condenser of like arrangement, and so on until the pressure of the steam can be no further reduced, at each conversion producing an additional quantity of distillate, when the last body of water, being evaporated, is used to replace the water evaporated in the previous cells and also in the primary boiler.



WATER DISTILLING APPARATUS IN MULTIPLE

An apparatus is provided wherein the concentrates from the water being purified are separated and stored for use as a valuable by-product.

These stills consist of 3 or more cylindrical vertical cells thoroughly enclosed in an insulating covering, bunched together in as compact a way as possible. The number of cells, or "effects," may be increased to any extent desired, resulting always in a saving in fuel, but not increasing the capacity or improving the quality, which is unvarying. One steam inlet from the primary boiler feeds the whole, as does 1 raw water inlet from the water supply; and the distillate unaerated and cooled to near the temperature of the feed water, issues in a single pipe, ready for use.

Stills vary in size of each cell from 5,000,000 to 1,000 gal. per day of 24 hr., the floor area depending on the number of cells used, or number of times the heat is re-used before being returned in the feed water. The latter also affects the price. Generally speaking, 1 horsepower of boiler can be depended on for 1,000 gal. per 24 hrs. operation in small stills; much more than this in the larger sizes, as for municipalities.

It is found far more economical to use the steam direct from the boiler than to employ exhaust steam, and frequently the steam is used first to produce distillate and then for any other purpose, as the steam in such cases is identical with that fresh from the boiler.

Experience has demonstrated in handling sea water with this apparatus, provided the water is preheated before evaporation, that very little scale forms, even after a period of 9 or 10 months.

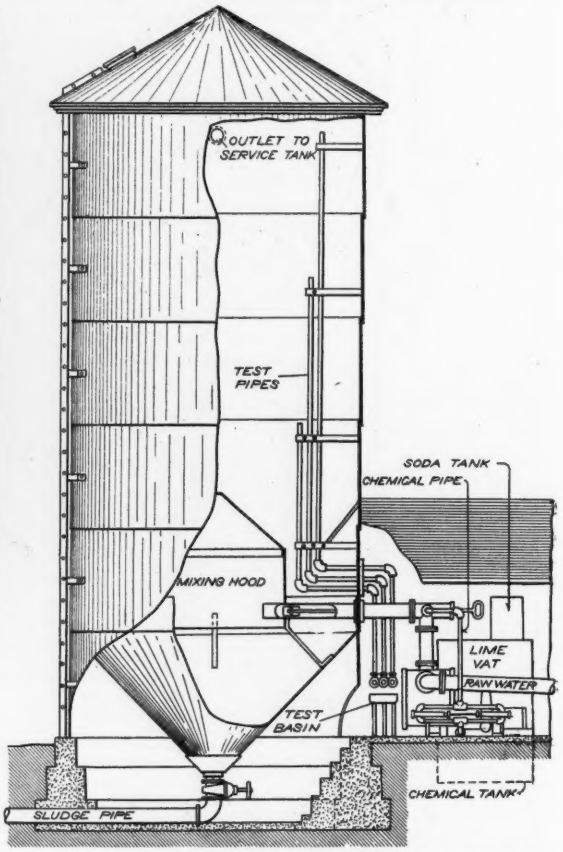


FIG. 1. MILLER TYPE CONTINUOUS WATER TREATING PLANT

In many cases, even where aqueduct water that will serve can be obtained, the cost is much higher than that stated above. In the Gulf States and many locations, like semi-arid lands, etc., where the water very quickly ruins a boiler, distillation alone seems adequate to the task.

MILLER TYPE CONTINUOUS WATER TREATING PLANT

Otto Gas Engine Works, Chicago

The Miller type continuous water treating plant, as built by the Otto Gas Engine Works of Chicago, consists of the Miller meter-motor and its auxiliaries, all set

on the ground floor together, and a settling tower. The motor is a proportioning machine, its auxiliaries are a chemical tank with stirring apparatus, not shown in diagram, a lime vat, and a soda tank; these are always housed in.

The tower is built up of steel plate, and has an outlet pipe near the top. It has a false conical bottom with a forty-five degree slope. With this slope it is found that the sludge will always slide towards the sludge pipe, when the valve shown at the bottom is open. A mixing chemical enters the water just before it passes into the mixing hood. In the mixing hood it is thoroughly agitated and then passes out at the bottom into the settling tank and slowly rises to the top. Chemical action takes place very rapidly in the mixing hood, being under high pressure.

The size of the tower is determined by the quantity and quality of water to be treated, and is made large enough so that the sediment is settled by the time the water has risen to the outlet pipe at the top.

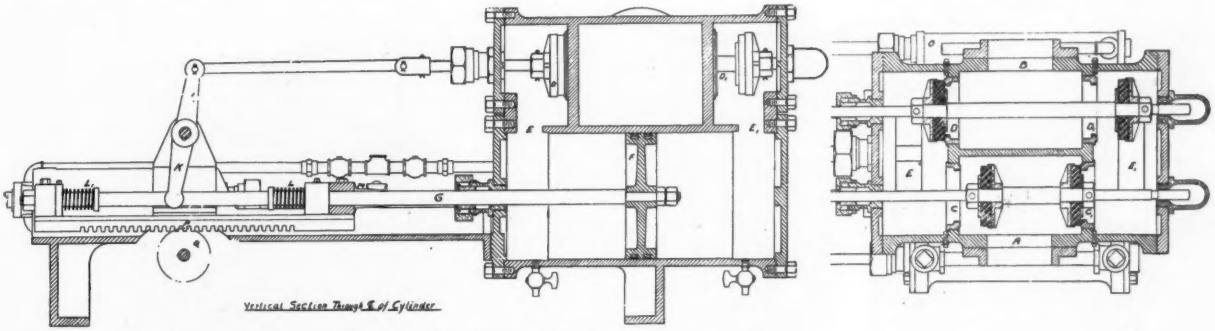


FIG. 2. MILLER METER MOTOR

hood is provided as much to prevent eddy currents as to mix the water with the chemical.

The Miller meter-motor consists essentially of a cylinder with a moving piston, acting as both a meter and a motor, the necessary valves, a set of chemical pumps, and an agitating device.

Referring to the diagram and considering the machine in operation, the raw water enters the machine at A, passes through valve C and port E, into the left hand end of the cylinder, and pushes the piston F to the right. The water in the right hand end of the cylinder is forced out through port E_1, valve D_1, and opening B, through the discharge pipe into the mixing hood of the settling tower.

In moving forward, piston F carries with it piston rod G and springs L and L_1, also rack P. When at the end of its travel, spring L_1 throws the rocker arm K forward, and arms J and J_1 backward. This opens valves C_1 and D, and closes C and D_1. Water is now admitted through A, C_1 and E_1 into the right hand end of the cylinder, forcing piston F to the left and the water out on the left hand end through E, D, and B. When at the end of this stroke, spring L through rocker arm K and arms J and J_1 changes the position of valves C, C_1, D, D_1 back to that shown in the diagram, and one cycle is completed.

Piston rod G is rigidly connected through cross-arm to the plunger rod of chemical pumps, so that there is a continuous flow of chemicals introduced into the water under pressure. By this direct connection the water is metered and the chemicals pumped in direct proportion to the water passing through the cylinder.

In operating the complete plant, the proper amount of lime is slaked in the lime vat, soda ash in the right amount is dissolved in the soda tank and added to the lime solution. The whole is now brought up to a certain volume. It is then run into the chemical tank and is pumped from there by the proportioning machine. In order to keep the milk of lime uniform, an agitator, actuated by rack P and pinion Q of the machine, is provided.

The raw water passes through the meter-motor, is measured and actuates the chemical pump, and passes through the discharge pipe into the mixing hood. The

The tower is provided with test pipes so that the operator can determine the condition of the water under treatment, and when necessary open the sludge valve at the bottom to blow off the sludge.

AUTOMATIC WATER PURIFIER, TYPE B, PATENT REISERT-DERVAUX

Purification & Engineering Co., 48 Church St., New York City

This is the type principally used by this company, and is constructed to treat water either by hot or cold processes. The chemicals used are lime and soda ash.

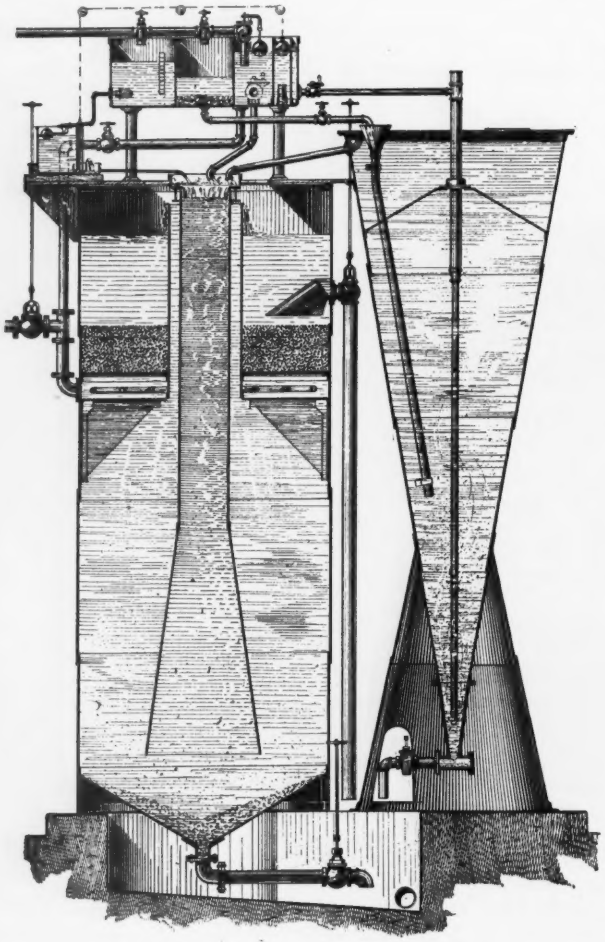
The apparatus consists of a distributing tank with compartments for raw water, lime slaking, and soda ash solution, a settling tank with mixing pipe and gravel filter embodied, and a lime saturator, all parts connected in such a manner as to form a compact apparatus.

The water to be treated enters the raw-water compartment of the distributing tank either by gravity or pump and the water level in this compartment is always kept constant by means of a float valve. An accurately regulated quantity of the raw water, depending on the amount of lime water needed, is run into the lime saturator and the balance goes directly to the mixing pipe. The quantity of lime needed for a day's run is slaked in the lime compartment and the milk of lime is drawn to the bottom of the lime saturator. The constant flow of raw water through the center pipe of the lime saturator carries the lime particles upwards until the velocity of the water becomes so small, on account of the increasing cross sections of the saturator, that the lime particles cannot follow. Consequently, the lime water, which has become completely saturated, always enters the mixing pipe perfectly clear and of uniform saturation.

The necessary amount of soda ash needed for a day's run is dissolved in the soda compartment and from there run by an automatically regulated syphon into the mixing pipe.

In this mixing pipe the raw water gets thoroughly

mixed with the lime-water and soda solution and is carried down to near the bottom of the settling tank, where most of the precipitated sediment is deposited. From the settling tank, the water flows to the gravel filter and after passing through this is discharged to the outlet pipe. The sediment accumulating at the



AUTOMATIC WATER PURIFIER, TYPE B, PATENT REISERT-DERVAUX

bottom of the settling tank and lime saturator can be drawn off from time to time by means of the sludge valves.

The filter bed is washed out daily by reversing the flow of water, using at the same time compressed air, produced by means of an ejector, for stirring up the filter material. If necessary, the apparatus is provided with a heater, using either live or exhaust steam, and placed on top of settling tank or embodied in same.

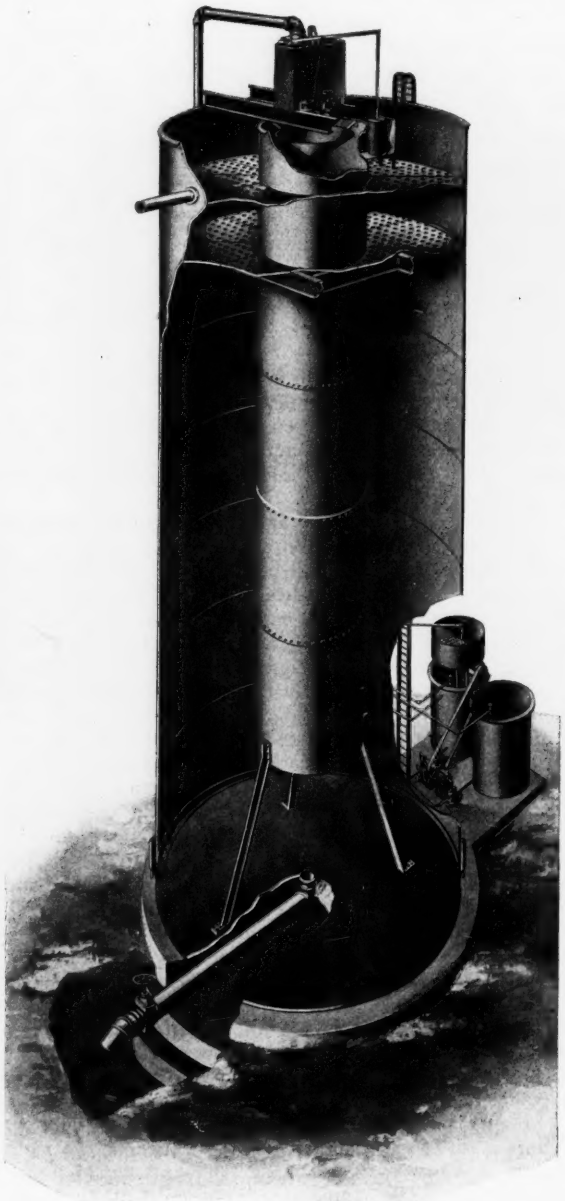
BARTLETT WATER SOFTENER

Northern Water Softener Co., Madison, Wis.

The Bartlett water softener is of a continuous type and automatic in its operation, and successfully removes from the water the mineral which causes hardness. The chemicals ordinarily used are lime and soda ash.

This system delivers a uniformly softened water for whatever purpose needed, and consists of 3 distinct parts, viz.: The chemical reagent tank, the chemical and water proportioning device, and the reaction and settling chamber. The proportion of chemicals used is based upon the analysis of the water to be treated. The chemical and water are automatically proportioned by means of the distributor located upon the top of the softener.

The lime is slacked and mixed with the soda ash in the upper chemical tank, from which it is drawn to the lower or agitating tank, where the mixture is made up with water kept in constant agitation by means of



BARTLETT WATER SOFTENER

twisted paddles. From this tank it is pumped to the chemical and water proportioning device. The water and chemicals are mixed in an inverted cone shaped receptacle, from which they overflow to the downtake pipe and flow to the bottom of the settling chamber,

then up through the wood wool filter bed, above which is the outlet to the boilers. The precipitates settling at the bottom of the chamber are drawn off through a sludge pipe at the bottom.

WE-FU-GO SYSTEMS

Wm. B. Scaife & Sons Co., Pittsburg, Pa.

Under the names given above this company manufactures both intermittent and continuous water softening and purifying systems, the systems being designed to meet, in each case, the specific requirements.

THE WE-FU-GO INTERMITTENT WATER SOFTENING SYSTEM

The We-Fu-Go intermittent system consists essentially of 2 or more treating and settling tanks, equipped with mechanical stirring devices operated by power, a small reagent or chemical mixing tank with mechanical stirring device and jet or other pump for introducing reagents into treating tanks, and a filter.

The treating tanks are filled alternately with water; while a tank is filling, the reagents are introduced and thoroughly mixed with the water by means of the mechanical stirring devices, consisting of a specially designed paddle, revolved by power from an available line shaft, an engine or a motor. The paddle not only mixes the reagents with the water, but at the same time stirs up from the bottom the lime sludge of preceding purification. This sludge floats in the water, hastens the chemical reaction, and causes the new finely divided precipitate to form large woolly flakes heavy enough to settle quickly as soon as the water stops moving.

After a tank is filled, the stirring device is stopped, and the water permitted to stand, in order to allow the precipitate to settle to the bottom of the tank. The softened water is taken out of the tank by means of a hinged floating outlet pipe, arranged to rise and fall with the level of the water, so that the water is always drawn from the top. The rate of flow to the filters is automatically controlled, so that they are supplied with water as fast as it is drawn from them. While 1 tank is being filled, treated and settled, the other is supplying treated water; and by the time it is empty the first tank is ready to use. In this way a constant supply of accurately treated soft, clear water is always on hand.

The We-Fu-Go continuous system consists of a tower tank containing separate lime reaction, soda reaction and settling compartments with mechanical stirring devices in the reaction compartments; tank for slaking lime and dissolving soda or other reagents; lime and soda solution tanks with mechanical stirring devices; pump of special design for introducing the solutions into the reaction compartments; electric or water motor or steam engine to furnish power for operating the mechanical stirring devices and solution pumps and either mechanical gravity or pressure filters.

With this system under certain conditions where it is desirable to use a lime water instead of cream of lime, a patented lime saturator is used. This system is automatic and continuous in its operation. The treatment is automatically regulated to the quantity of water passing through; the speed of the pumps introducing the reagent solutions being governed by the volume of water entering the system.

RAYS CHEMICAL MECHANICAL WATER PURIFIER AND BOILER CLEANER

The Ray Steam Specialty Co., Wichita, Kan.

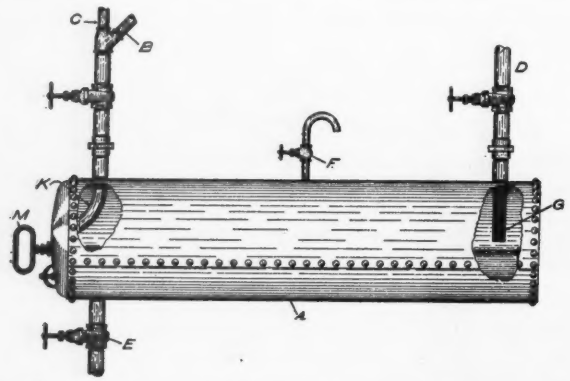
The boiler cleaner shown in the illustration is designed to prevent the formation of scale and sediment in a steam boiler by purifying the feed water before it enters the boiler, by the use of reagents when necessary, and by treating the feed water in the machine, instead of in the boiler; thereby eliminating the foreign matter from the boiler.

By an analysis of the feed water to be used it can be ascertained whether it be necessary to use a reagent in connection with the machine; when necessary it can be introduced by attaching an apparatus for feeding it, either to the feed water pipe, C, or the inflow pipe, B, as shown in the cut.

By taking a volume of hot water from the boilers with the pipe B, which is inserted just above the flues and below the level of the water in the boiler, a continuous surface blowoff is secured. Hot water or steam passes into the machine A, and from there back into the boiler through strainer G and pipe D, making an efficient skimmer, and getting a sufficient amount of hot water, with which to treat feed water, and absorb the reagent, if one is used, and mix it with the feed water as it passes to the machine, getting thereby

a perfect chemical change in the feed water in the machine, and before it enters the boiler.

The elbow K, inside of the machine, which is attached to the inflow pipe, forces the water into the oval end of the purifying tank, causing an eddy to form and breaks the force of the pump or injector,



RAY'S CHEMICAL MECHANICAL WATER PURIFIER AND BOILER CLEANER

which feeds raw water through the pipe C, and facilitates the settling of the foreign matter, in the machine. For removing sediment a scraper M and blowoff valve E are provided and floating precipitates and scum are discharged through the valve F.

Water taken from a high pressure boiler in this manner and mixed with the feed water, raises the temperature of the feed water so high that all of the carbonates are precipitated in the machine without the use of the reagent.

VATER CONTINUOUS WATER PURIFYING SYSTEM.

Power Plant Specialty Co., Chicago, Ill.

The essential parts of this hot process for purifying water consist of a mixing tank, solution tank, heating chamber, settling chamber, filter bed and necessary accessories. Soda ash is dissolved with warm water in the mixing tank from which it is drawn to the solution tank below. From the solution tank the chemical is pumped to the cold water inlet pipe. The chemical pumps are operated by means of systems of proportioning levers from the piston rod of the main boiler feed pumps. By this arrangement any desired proportion of chemical to the raw water used may be obtained.

The cold water entering the heater through an automatic valve and inlet pipe is mixed with the weak chemical solution before entering the heater and is discharged into a long trough with serrated edges. Overflowing from this trough the water is sprayed into a series of pans which divert it back and forth through the heating chamber, thus heating it to a high degree and causing it to deposit all the scale-forming materials held in solution.

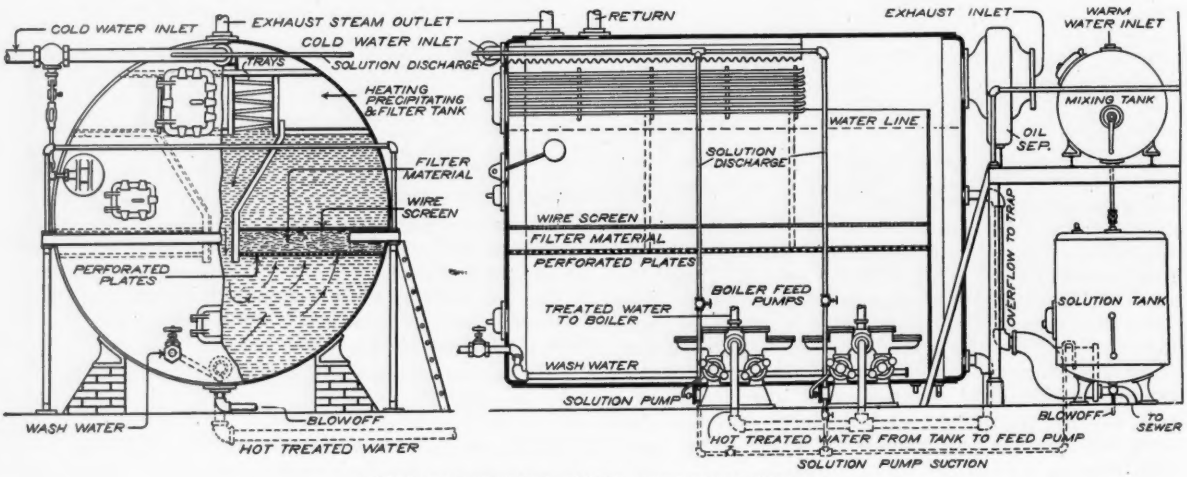
From the lower tray the water is discharged into a funnel-shaped downtake and is drawn to the settling chamber below the filter bed. Here the precipitates and sediment are deposited at the bottom of the settling chamber and may be drawn off through the blowoff shown at the bottom where also a wash water pipe is provided.

The water passes upward through the filter bed, which is held in position by screen plates keeping a uniform thickness of filtering material. After passing through the filter bed the water flows to the back of the heater and is drawn off at the bottom to the boilers through the feed pumps.

Exhaust steam enters the heater through the oil separator which effectually removes the entrained oil and condensed steam and passes into the heating chamber and out at the exhaust outlet near the front.

Doors are provided for removing the trays and filtering material and make access to the entire interior of the heater easy. Little scale matter collects on the pans, as they are shallow and are set at such an angle that the water flows rapidly over them, allowing only sufficient time for the water to become heated, the precipitation taking place in the settling chamber.

"NEVER WAIT for a thing to turn up. Go and turn it up yourself. It takes less time, and is surer to be done."



VATER CONTINUOUS WATER PURIFYING SYSTEM

A BOILER HORSEPOWER means the evaporation of 30 pounds of water from 100 deg. F. to steam at 70 lb. gage pressure, or 34.5 lb. of water and at 212 deg.

BOILER COMPOUNDS

Boiler compounds so-called are really a special form of feed-water treatment applied to the water as it passes to the boiler. There is no reason except that of convenience why any of the boiler compounds cannot be used outside the boiler as well as inside and in cases where there is a large amount of water to be treated and a large amount of incrusting solids to be disposed of, it may prove to be better policy to use the compounds before the water is sent to the boiler, then all the sludge formed may be deposited in a settling tank, rather than carried into the boiler with the water and blown out again.

If there is but a small amount of scale-forming material, either because the water is reasonably good or because the total amount of water used is not large, the treatment of the water directly in the boiler so as to make the scale harmless, that is, convert it into a loose deposit which can be readily washed out, will be found the most economical method of treating. The object of the boiler compound is to convert such salts as would form into hard scale cementing itself to the boiler plate or tubes, into a powdery deposit or soft mud which can readily be removed. This sludge is taken out partly by the use of the blowoff valve, partly by surface skimming and partly by washing out with the hose at such times as the amount of deposit makes advisable.

Where the water is treated before sending it to the boiler the scale-forming material thrown down may be removed either by slow settling or by a filtering process.

In using any kind of compound it is, of course, important that the remedy should fit the disease, that is, the boiler compound must be suitable to take care of the impurities in the water treated. It is a fact worth noting that the chief incrusting solids in boiler waters are carbonates of lime and magnesium and sulphate of lime. By treating the water so that the sulphate of lime, which ordinarily forms a hard scale, comes down in a loose powder in the form of carbonate, and by adding some ingredient which will take care of any possible oils or greases, most waters may be made reasonably satisfactory so that a compound may be devised which will do good work on the great majority of boiler waters.

If however, absolutely accurate treatment of the water is sought, and this is always desirable, it is necessary to have the boiler compound mixed especially for the water in each plant, both because no 2 boiler waters are found to be exactly alike as to their impurities, variation being either in the kind of impurity or in the relative amounts, and because with different relative amounts of impurities in water the reaction of corrective chemicals upon these impurities works out differently.

The amount of compound to be used will vary with different waters even where a single average formula is used for the treatment of different kinds of water One point that is essential in any scientific analysis is that the sample sent for analysis shall accurately represent the water as ordinarily supplied to the boiler. The water must be taken from a point where there is not special collection of impurity; it must be kept away from contact with the air during shipment and must be sent in a vessel from which no impurities can be collected by the water.

A new earthenware jug is not usually a good vessel in which to ship a sample of feed water, as unless the glazing is very carefully done the water may absorb some impurities from the clay of the jug. A glass bottle which has been carefully washed out with acid and afterwards with distilled water until it is absolutely clean is the best containing vessel for making shipment.

SOME FACTS ABOUT BOILER COMPOUNDS.

BY A. EUGENE MICHEL

The majority of scale-forming and corrosive elements in feed water can be effectively and economically prevented from doing harm by the careful use of a scientifically prepared boiler compound, bearing in mind that we refer only to compounds correctly prepared and used.

You can deal with scale-forming elements in three ways: 1 by treatment of feed water before it enters the boilers; 2 by treatment within the boiler; or 3 by scale removal at periodic intervals.

The first 2 methods apply also to corrosive elements, which must be rendered absolutely harmless as soon as discovered, if the boiler is to be preserved. If scale and crrosion are to be prevented by external feed water treatment, there is required additional apparatus in the form of a purifier, filter, settling tank, separator, or a combination of these which require a considerable outlay for apparatus.

If, on the other hand, the feed water impurities are permitted to form scale an initial expenditure becomes necessary for cleaning apparatus, which in itself is a source of repair expense. There is a fuel loss, often amounting to 25 per cent when scale is less than ¼ in. thick. Nor does this take into consideration the repair expense, when scale causes tube ends to leak, or heating surfaces to blister. Replacing tubes is also a common expense when scale is very thick and hard.

The use and action of boiler compound is quite easy. As compound acts entirely within the boiler, no other apparatus save a feeding device is required, which, as a rule, may be obtained free from the manufacturer of the compound. The engineer has only to spend a few minutes each day in renewing the supply of compound to keep the heating surface clean and at highest efficiency, the boilers need only be blown 2 or 3 times a day, and occasionally washed out with a hose.

There is no investment save the cost of the compound. If the compound is correctly prepared and used, there will be found, upon emptying the boiler, nothing but a little soft mud which may be washed away with water, or if allowed to dry, may readily be blown away as dust.

But success with any boiler compound depends upon its being adapted to the feed-water, and upon using the right quantity to accomplish the purpose. It is simply the neglect of these conditions either by an unscrupuous manufacturer or by the user that causes dissatisfaction with compounds.

Waters carrying a large percentage of impurities require a proportionately large percentage of chemicals to render these impurities harmless, while waters of a better composition carrying a small amount of impurities require a lesser amount of chemicals to counteract the scale-forming and corrosive tendencies.

Again, there is variation in the quantity of each im-

purity in different waters, and the amount of the chemicals in the compound must be varied for each individual case. Just what this might mean to a boiler owner may be judged from the difference between the impurities in the following 2 waters, for the analyses of which the writer is indebted to the Bird-Archer Co., manufacturers of Bird-Archer boiler compound:

	No. 1. Grains Per Gal.	No. 2. Grains Per Gal.
Solids	22.829	39.923
Organic and Volatile Matter	1.011	6.235
Sodium Chloride	3.415	5.239
Sodium Carbonate	11.170	.....
Sodium Sulphate	1.450	4.101
Calcium Carbonate	2.452	2.145
Magnesium Carbonate	1.516	1.923
Iron Oxide and Alumina	.714	.....
Silica	1.101	.....
Free Carbonic Acid	6.511	14.141
Calcium Sulphate	.....	16.038
Magnesium Sulphate	.....	4.242

The above 2 samples are chemically opposite. No. 1 is of an alkaline nature and under the influence of boiler heat and pressure would tend to foam and prime. The scale from this water would be like mud. As the water inside the boiler would be converted into steam, the sodium salts would concentrate in solution in the water, increase the density of the solution, and retard free steaming. If this water was treated with a boiler compound containing alkalis, the harmful constituents already present would do still more harm and increase the foaming tendency.

Sample No. 2 tends to form a heavy crystalline scale, so hard, that if struck with a hammer it would chip like procelain. In addition to chemicals required to neutralize the various calcium and magnesium salts in solution, the compound should, in this case, show an alkali reaction.

Anyone, who whether through ignorance or indifference, totally disregarded the individual conditions of these 2 samples and used the same compound in both plants would commit an offense which is nothing short of criminal. The interior of a boiler is no place for experimenting.

It is peculiar that if the 2 waters were mixed, a heavy precipitate due to the action of the impurities of one upon those of the other would occur and greatly improve both waters. This is just what the compound does, as well as rendering the precipitate nonadhesive. It is clear that the compound should contain the right amount of each of the right constituents to do its work well. It is also evident that this is a matter of individual investigation for each plant, by a competent chemist and then of following his instructions carefully in applying the remedy he offers.

That there is nothing to fear from the use of boiler compounds when these conditions are heeded may be inferred from the guarantee of the Bird-Archer Co., of New York, which has, for the past 10 years, been furnishing its product to any plant on 6 months trial during which the company assumes the risk.

In so doing, it should be stated, however, that it puts its customers and itself on the safe side by filling no orders until a competent staff of chemists has analyzed the water or samples of scale from the plant where the compound is to be used.

Explicit instructions go with each shipment of compound, and where these were followed, there has been no difficulty in preventing corrosion or scale formation. It is even practical to use compound to dissolve old scale of long standing, and this can be done without in any way injuring the boiler, its fittings, packing, gaskets, or "cutting" the cylinder lubricants.

A properly prepared compound will not cause the boilers to prime or foam, and it will not contaminate the steam in any way to affect products which come into contact with it.

PYRAMID COMPOUND.

Binghamton Boiler Compound Co., Binghamton, N. Y.

This company believes that the only true, correct and scientific method of procedure in treating boiler feed waters is analysis of the feed water first and making of the compound afterwards. They ask for a half-gallon sample of the boiler feed water or a sample of the scale, and, after chemical analysis, the compound is prepared to be used according to directions given, and the company guarantees that if so used a clean boiler will result.

The analytical department has a complete chemical laboratory in charge of licensed chemists, up-to-date in every particular, and a factory equipped with the best machinery for compounding the different chemicals. Besides its "results or no pay" method the company guarantees that its treatment will not injure boilers, packing or lubricants.

NEUTRALIZING FEED WATER IMPURITIES.

By Louis N. Sahm.*

All natural waters carry mineral impurities owing to the property of water to dissolve everything with which it comes in contact in large or small amounts. Water originates from rain and snow, and in this condition is pure, but as soon as it reaches the ground it becomes impregnated with mineral constituents by percolating through the earth and coming in contact with Limestone, Marble, Gypsum, Dolomite, etc. We thus upon analysis, find waters to contain Calcium Carbonate, Sulphate, Chlorides, Magnesia, Iron Oxide, Carbonic Acids, etc.

The mineral constituents of a water do not have a harmful account upon the health of the human body unless present in very excessive amounts, but the same water used to develop power by conversion into steam, deposits a rock accumulation agreeing with the original material which was dissolved by percolation of water through the earth.

It is difficult to realize the large amount of mineral matter in the water used by a steam plant to develop power. Take an average water carrying 20 grains of solids per gallon in a 100 hp. boiler working 12 hr. a day; it will deposit 411 lb. of scale in 30 days, as this size of boiler will evaporate 144,000 gal. of water in that time.

Now this must be corrected and prevented as such accumulation upon the sheet and tubes of a boiler not only causes large losses of fuel, but also great expense for repairs due to blistering of the sheets, bulging, corrosion, pitting and grooving, and often explosions. Thus has developed a natural demand for a mixture of chemicals, compounded according to the analysis of the scale or water, which will not only remove old formation, but also prevent new accumulations and also stop all corrosive action from the acid properties of the feed water.

*Chief Chemist, the Cherry Chemical Co., Philadelphia, Pa.

Just as we find different impurities in a water supply, so we must use different chemicals to neutralize and decompose: also, as the percentages of these impurities vary, so must the percentage of the various chemicals be varied. No one mixture of chemicals will answer for all cases, any more than a patent medicine will answer for all ails.

Also the quantity of chemicals necessary to neutralize a water must vary according to the percentage of impurities found in the water supply by analysis.

BANNER BOILER COMPOUND.

The Cortland Specialty Co., Cortland, N. Y.

This compound is devised to soften the water and reduce corrosion and scale. The treatment is based on chemical analysis of the water, the importance of such an analysis and providing proper treatment being shown by the facts stated by the company that 1-16-in. scale means 13 per cent fuel loss; ⅛-in. 22 per cent loss; ¼-in. 38 per cent loss; ⅜-in. 50 per cent loss; ½-in. 60 per cent loss, and ¾-in. 91 per cent.

In using the Banner compound the directions given are first to wash the boiler thoroughly so as to remove all loose scale. Then for each 100 hp. use 1 gal. for the first day and ½-gal. daily for 30 days thereafter except that 2 days before cleaning the boiler a gallon should be used. The Banner compound weighs 10 lb. to the gallon. The methods of feeding recommended are by pump, injector, gravity flow into the feed-water tank, or a bypass on the feed pipe. Blowing down is advised every day after the boiler has gone into service, the sediment then being suspended.

After a boiler has been cleaned of scale, the amount of compound used is to be reduced to ½ of the amounts given above. The Banner compound is warranted to be harmless, so that live steam may be used from the boilers for the manufacture of food products, breweries, etc.

In order to use economically it is recommended that the head of the barrel be removed and the solution dipped out as required. If crystals form about the edges they may be dissolved by adding hot water, full strength of the solution being maintained until all is gone. The chemicals are mixed with a hot process so that there is no danger of the chemicals themselves evaporating, although the crystals may form.

TYPICAL WATER ANALYSES

By W. A. Converse*

The troubles of steam engineers and steam plant operators are many, and no greater amount of trouble arises from any of the materials or substances used in or about the steam plant than from the feed water used in the boilers. Consequently the subject of water treatment has demanded very serious and extensive consideration throughout a long period of time; and during the last 20 yr. many methods, processes, etc., have been advocated, brought forth, and tried out in practice, with results varying from those which could be pronounced practically perfect to those which were extremely objectionable on account of their not in any manner alleviating the trouble, but rather in many cases increasing the difficulties already experienced, or giving rise to troubles which had previously been unknown at the plant under consideration.

*Chemical Director Dearborn Drug and Chemical Works, Chicago, Ill.

While by many people not conversant with the wide differences existing, waters are considered "waters," from the knowledge obtained in the analyses of upwards of 30,000 different waters during the writer's experience of the past 20 yr., this assumption is very strongly demonstrated to be fallacious. It has always been more or less noticeable that different waters give widely varying results in practice, under like conditions; and many times like waters give widely varying results under unlike conditions. This naturally would lead to the conclusion that the varying results alluded to in the former case must necessarily be due either to variance in quantity of certain solid substances common to the waters, or to the presence of different kinds of solid substances contained in solution in the waters themselves. Following this assumption, it was concluded to be absolutely necessary, by those who are making a special and specific study of the proposition, in order to determine the cause of the results or effects obtained in practice, to make analyses of the waters being used.

This method being followed for a sufficient length of time, it was found that it was not difficult to reverse matters and precede the inauguration of the use of the waters in the boilers by a complete mineral analyses at the hands of some man who had made a sufficient study of the proposition to become an expert in the line and be able to foresee with certainty the results or effects which the water would have in actual practice. This means that in order to handle the subject intelligently, it is necessary, first of all, to make or have at hand a complete mineral analysis of the solid matter contained in the feed water.

While it is very generally and conclusively shown that many chemists consider the only troubles arising from the feed water to be those due to scale or incrustation, and only a partial analysis is made, in other words, a determination of the hardness, temporary and permanent, which gives, in a measure, evidence as to the amounts of carbonates and sulphates of the alkali earths; or by other methods, the total amount of solid matter present which would under the conditions deposit in form of incrustation is determined, it will be noted that in referring to analysis of water we mention complete mineral analysis.

An analysis of this nature is absolutely essential in each case, as there are as many plants in the States today, taken as a whole, experiencing trouble entirely due to the alkali salts, namely, sodium and potassium chlorides, sulphates and carbonates, as there are plants where the trouble is due to the lime and magnesia salts which enter into the formation of scale. The effect of these alkali salts is to cause trouble in the form of foaming, priming, etc., together with corrosive action on the surfaces of the sheets and tubes, oozing out at and causing leaky joints, destruction of gaskets, etc.

This is not a theoretical conclusion, these effects having been demonstrated hundreds of times in actual practice. Many waters which carry a sufficient amount of incrusting solids to give rise to trouble in the form of scale do not do so, owing to the fact that they carry an equal or larger amount of the salts of the alkalis above named. This fact demonstrates that it is necessary to consider the proportionate amounts of the several salts shown to be present, as well as the total quantity of each.

The company with which the writer has been connected for the past 15 yr. as chemical director, following the above conclusions, was one of the first to in-

augurate the system of making analyses of waters, maintaining thoroughly equipped laboratories, and employing a corps of competent chemists for the purpose of executing this work. And since the inauguration of these methods, as well as at the present time, and for the future, the policy of the company has been and will be not to pass upon the quality of any boiler feed water, or recommend any treatment whatever, without first having at hand a proper analysis of the water, and detailed information as to the conditions existing in the plant itself. A complete mineral analysis constitutes the derivation of all of the substances shown in the following table, which gives the results of analyses of several different samples of water:

THE FOLLOWING RESULTS ARE GIVEN IN GRAINS PER U. S. GALLON:

	NO. 1	NO. 2	NO. 3	NO. 4	NO. 5	NO. 6
SILICA	0.502	1.576	0.595	0.163	0.245	0.584
OXIDES OF IRON & ALUMINIUM	0.093	0.280	0.116	0.151	0.175	0.116
CARBONATE OF LIME	0.234	TRACE	8.783	2.703	4.978	4.118
SULPHATE " "	NONE	44.989	TRACE	4.836	19.026	0.781
CARBONATE OF MAGNESIA	0.407	11.339	4.569	0.707	12.404	2.371
SODIUM & POTASSIUM SULPHATES	8.214	12.404	1.836	11.455	87.758	0.217
" " " CHLORIDES	13.600	4.590	3.042	6.800	1.360	0.340
" " " CARBONATES	22.789	—	—	—	—	—
LOSS ETC.	0.180	0.040	0.097	0.105	0.431	0.196
TOTAL SOLIDS	46.019	75.218	19.038	26.980	126.377	8.663
" INCRUSTING SOLIDS	1.236	58.184	14.063	8.620	36.828	7.910
" NON-INCRUSTING SOLIDS	44.783	17.034	4.975	18.360	89.549	0.753

The extreme variance shown should be conclusive evidence that there can be no 1 specific treatment produced for use with any and all waters, which will work efficiently. Nor is it possible to classify waters into 2 or 3 types and recommend 1 treatment for each type which would give thoroughly satisfactory results from every point of view, or with each individual water.

Upon reference to analysis No. 1, it will be noted that the total incrusting solids are equivalent to approximately 1.25 gr., while the non-incrusting solids amount to virtually 44.75 gr. Waters of this type do not cause trouble in the form of scale formation, but, as intimated earlier in this article, produce very serious trouble in the form of foaming and priming; and said action is so intense that it is practically impossible to overcome the trouble experienced. Since it is impossible in practice to remove these substances from the water by any method of treatment, they necessarily go into the boiler with the feed water.

This is prima facie evidence that, in order to overcome the trouble so far as possible, it is necessary to apply treatment in the form of a proper chemical or mixture of chemicals, that will counteract the effects or offset the action of these substances.

In analysis No. 2 we have a water heavily laden with incrusting solids, and at the same time carrying an appreciable amount of non-incrusting solids. This water would have the effect of producing, under practically all conditions, much trouble in the form of incrustation, causing the deposition of a comparatively large amount. The formation would be decidedly hard, impervious and persistent, due to the proportionately large amount of sulphate of lime present as compared with the total incrusting solids. It would also undoubtedly cause trouble in the form of corrosion and pitting, not, however, due to the presence of sodium and potassium salts, but to the fact that the sulphate of lime composing the scale which lies in direct contact with the sheets or flues becomes decomposed after the scale has formed to moderate thickness, liberating sulphur acids which, having a strong affinity for the metal of the sheets or tubes, would take hold of it and produce the trouble referred to. With this water both of the actions described are decided, and both are oft-times extremely serious, as the corrosion may be going on unnoticed beneath the scale formation present.

In analysis No. 3 we have a water carrying, comparatively, a large proportion of incrusting solids, but with a complete absence of sulphate of lime and a comparatively very low content of sodium and potassium salts. Ordinarily it would be presumed that a water of this type would cause trouble in the form of scale or incrustation only. Such is not the case, however, as under ordinary operating conditions the water will cause equally as much trouble in the form of foaming and priming as in the form of scale, owing to the readiness with which the greater portions of the carbonates of lime and magnesia present are precipitated as an extremely light, oozy mud, and in this form giving to the water a very decided tendency to foam and prime. And a slight excess pulling or crowding of the boilers would produce similar results.

Consequently it is necessary that with the use of this type of waters, the boilers be washed as often as possible, not only to avoid an accumulation of mud and thereby prevent foaming, but also to obviate the accumulation reaching a point where it would not readily circulate but would settle down in quantities upon the interior surfaces and, due to continued heating, become hardened, in this way becoming as objectionable as ordinary scale formation.

In analysis No. 4 a water is shown which will cause troubles of 2 kinds: It will deposit about an average amount of a decidedly hard scale, the hardness, etc., being due to the sulphate of lime present; and under most conditions it will also cause foaming and priming. The sodium and potassium chlorides in this case, together with the sulphates, are present in sufficient quantity to indicate that there will also be some trouble experienced in the way of corrosion, pitting, etc.

In No. 5 is shown a water which, ordinarily, should be pronounced unfit for use as a steam boiler feed supply. However, as many plants all through the country are dependent for their boiler supply on waters as bad and often many times worse than this one, we are compelled to place ourselves in a position to devise methods which will give them sufficient relief to enable them to operate their plants, by reducing the destructive action of the water to a minimum.

From the above no doubt some conception can be formed of the variance in the kinds and quantities of solid matter contained in different waters.

There are many other types of water encountered in steam plant operation, 1 of which is very common, and always demands serious consideration. To this type belong waters in which the solid matter contained is extremely low. In other words, the waters are, as a class, poor, and in many cases objectionable, on account of their extreme purity; that is, freedom from solid matter in solution. As an example of this we have rain water, which is known to be extremely destructive to the metal constituting the boiler, on account of its highly corrosive or oxidizing effect.

Distilled water, being practically the same as rain water, except possibly being devoid of traces of very small amounts of gases which the latter picks up during its fall, belongs to this class and has an equally destructive action upon the metals with which it comes in contact in boiler practice. Troubles of this kind also arise to a less or greater extent in all plants which are running condensing, and the condensed steam constitutes a large part of the feed water used.

No doubt this effect is due to 1 of 2 conditions, or, in some cases, possibly both. It is a well-known fact that water is the greatest solvent known, and has a solvent action upon all substances, even metals. On many substances, however, this action is appreciated to be very small, but there is positively no question that waters of this type do have a directly solvent action upon the metal with which they come in contact, and by a direct process of solution cause a removal from the surface of more or less of the metal itself, thereby showing results ordinarily referred to as grooving, pitting, etc.

It is also reasonable to expect, especially in high efficiency plants, that water at the point of contact with the heated surfaces is to a greater or less extent decomposed, liberating either free oxygen or what is known to chemists as hydroxl radical, the latter being a combination of 1 atom each of hydrogen and oxygen, either of which would have a very high oxidizing action upon the metal. This action can be very readily demonstrated and understood when it is shown to be possible by experiment to decompose water into its gaseous constituents, hydrogen and oxygen, by plunging hot metal into it. If such decomposition will take place under these circumstances, which it is positively known to do, we can reasonably expect that a partial decomposition can readily take place under many conditions existing in steam boiler practice.

It is necessary for anyone considering the proposition of boiler feed waters to consider each individual water by itself, and to confine himself to no specific preparation or specific application of any preparation whatever. In order to obtain the best possible results he must, first of all, be entirely conversant with the subject and understand thoroughly the effects of the different waters, due to the salts and the proportionate amounts thereof contained, know the proper chemicals to offset them, and be able to conclude whether it is possible to obtain the best results by the application of such preparation directly into the boiler, or into precipitating tanks alone, and in either case, whether a single preparation should be applied in both ways, or whether 2 or more distinct preparations should be used.

Many waters are so heavily laden with incrusting solids that it is impossible to give satisfactory results without first bringing about a removal of at least a portion of these solids. In such cases, the application of a method of outside treatment whereby the greater portion of the incrusting solids can be precipitated and removed, either by filters or by sedimentation, is advisable. It has been shown in practice, however, that with waters treated in this manner, due to the by-products formed from the chemical reactions which have taken place during the treatment, which by-products, by the way, are extremely soluble in water and cannot be further separated, it is necessary to use a suitable treatment in the boilers direct, to offset the deleterious effects of said by-products.

Again, going back somewhat to the earlier part of this article, it is equally essential that provision be made in any treatment to be used directly in the boiler, to obviate and counteract the effects of any by-products which may be formed by reactions which would take place between certain constituents of the treatment itself and the salts contained in the water as fed into the boiler.

The writer is more thoroughly convinced from week to week of the importance of a thorough and complete and accurate analysis of the water under consideration, in the determination of the substances named above; and that the treatment of waters for this purpose is not given the serious consideration by many that it should have. Those who are apparently not giving the subject the serious consideration it demands are devoting most of their time and energies to a specific line different from the one being considered, and those who have not gone into the subject thoroughly and carefully are inclined to think that the water is not of sufficient importance, or that the results obtained from scientific treatment of it are not such as to justify the years of careful and serious study necessary in order to understand the handling and treatment of waters, and judge of the results or effects that will be obtained from the use of the various classes and kinds thereof.

SOLVENTINE.

W. R. Du Mond, New York, N. Y.

This is a compound in dry powder from which is readily dissolved in warm water, 1.5 lb. of the powder making a gallon of liquid. If kept covered in a dry place it will not cake or harden but remains as a powder for any length of time. The maker offers to sell it under any required guarantee, put up in barrels, half-barrels and kegs.

U. S. STANDARD BOILER COMPOUND.

Eagle Oil & Supply Co., Boston, Mass.

This company examines free of charge water and scale sent to it, a gallon of water being asked for, shipped in a clean jug or bottle and also a sample of the scale which is formed from the water. The compound is made up in 5 brands known as 1, 2, 3, 4 and 5. Compound is shipped to reputable steam users on 60 days' trial, no charge being made, if the goods do not perform the service as represented. The directions for use are that ¼-lb. of compound shall be used per horsepower once a week, preferably on Saturday before shutting down, for 3 successive weeks. The boiler is not to be blown down for 48 hours after using the compound. At other times it should be blown down 1 gage just before starting up in the morning and at noon. When opening up the boiler it should be washed down thoroughly and examination made of the bottom.

CASE METAL BOILER CLEANER.

Globe Boiler Compound Co., Binghamton, N. Y.

This consists of a number of metal balls of compound hung in a cast-iron container and placed within the boiler. The balls are renewable as fast as the action of the boiling water dissolves them and are compounded to remove old scale, to prevent the formation of new and avoid corrosion. Three months is allowed in trial of the efficiency of this method of treatment.

HAWKEYE COMPOUND.

Hawkeye Compound Co., Chicago.

This is a dry compound, put up in the form of bricks which can be handled like any other brick material. It is dissolved in water as wanted and fed to the boiler by any suitable compound feeder.

KOMPOST BRICKS AND THE DEHN COMPOUND INJECTOR.

Compound Injector and Specialty Co., Chicago, Ill.

This is a water softening device which treats the water by passing it over a molded brick of compound,

this brick being held in a cage in the injector. The injector is installed in the suction pipe to the pump so that part of the water is carried through the injector body over the brick. The amount of water that is thus carried over the compound is regulated, of course, by the 2 valves. The brick will dissolve in either hot or cold water. The injector is made in sizes to fit pipe from ¾-in. to 2 in., the ¾-in. being intended largely for industrial plants and the sizes from 1¼-in. to 2 in. for feed-water heaters and boilers.

REMOVING SCALE BY MECHANICAL ACTION.

The H. W. Johns-Manville Co.

The problem of feed water purification has probably received more attention than anything alse in steam plants.

A small portion of the earthy carbonates are deposited as soon as the water is warm, another portion after considerable boiling, while some remain in solution even in boiling water. The soluble salts all pass into the boiler, and much of the dissolved carbonates also, and the intense heat of the iron in the boiler itself has an affinity for this suspended matter, attracting and baking it thereto. Thus while an analysis of water determines the chemicals necessary to purify it, the main object is not accomplished, viz., the prevention of this baking process.

Again, water is always undergoing constant changes, picking up more of the troublesome substances in long dry spells, and less in wet ones; and a treatment of the water by means of a chemical compound that will produce good results at the time the water is analyzed might possibly have the opposite effect at another time, and even make a scale of its own that is harder to remove than the original.

In trying to overcome the scale difficulty there is liability of using some chemical that not only attacks the scale, but also the iron, or when carried over with the steam, eats out the packing, or when the rods, and last but not least, affecting the lubrication to the extent of cutting the cylinders of the engine. Hence, the dream of the engineer has been to find something that will not only eliminate scale troubles, but also overcome any tendency to shorten the life of any particular part of his plant.

After years of study and experimenting this has been accomplished by a Seattle firm. Starting with the fact, as a basis, that all scale is full of fine cracks, which are caused by the expansion and contraction of the iron in a boiler, they began to look for something that would have a greater affinity for the hot iron than the soluble salts of the water; something that would work through these fine cracks and by coating the iron itself produce a mechanical rather than a chemical or dissolving action. This coating necessarily must be very thin, in fact more like a sweat than a coat, in order not to retard the heat units.

After finding the preparation that would do this, they also discovered that it had many remarkable and unlooked for features. This preparation not only removes scale in a boiler and prevents a new formation, but also has the tendency to stop up small leaks. It works its way through the cracks and as soon as the outside air and dust strike it, it hardens and practically cements the opening shut.

Chemicals that dissolve scale sometimes cause considerable foaming trouble, but as this preparation does not eat or dissolve old scale, this trouble is eliminated, and in many instances has been used successfully to prevent it. As it will not evaporate in the boiler, it is impossible for it to go over with the steam, a very desirable feature where steam enters into or is used in a product, such as cold storage warehouses, breweries, ice plants, etc. In short, its effectiveness is all in the proper place, viz., inside of the boiler, staying there and putting a protective coat on the iron, that even pure water will not effect.

Another peculiar feature of this preparation is that it appears to season or condition the iron so that the amount used can gradually be reduced to the minimum, in which the quantity of water evaporated makes no difference. It is put up in the form of a thick syrup which can easily be fed into a boiler, does not evaporate, settle, or deteriorate with age. As far as actual use is concerned, it has been submitted to the hardest of tests before adoption and indorsement by the largest and best railroads and steam plants throughout the country, including the different branches of the U. S. Government.

LORD'S BOILER COMPOUNDS.

Geo. W. Lord Co., Philadelphia, Pa.

This company attributes its phenomenal growth to moderate prices, expert analytical investigation, practical mechanical skill and careful formulation of chemical preparations to conform with exactness to the particular requirements of each case. Chemical preparations are mixed according to the most modern principles, as laid down by American and European experts who have devoted a lifetime to this branch of chemical research, and in accordance with the latest advances in the art of chemistry. These compounds have been before the public for more than 40 years, and have been sent all over the world. The plant was established in 1865, at Philadelphia, by George W. Lord, and has steadily grown. This growth has been due to careful management, industry, enterprise and high standard of products. The works are equipped with improved chemical appurtenances and machinery; they employ only the best of labor which has been carefully trained in the establishment, all departments being under capable and experienced managers.

These compounds are composed of soluble, non-corrosive crystalline basic salts prepared in dry granular form after careful chemical analysis of both water and materials, to meet each customer's requirements. They are devised to transform the mineral matter contained in boiler feed water from elements which form hard scale into inert earthy oxides which have no capacity to solidify, and the compound is designed also to neutralize all free acids present in the water. The chemical action on scale formations is the same as in the natural process of rock disintegration constantly occurring on the earth's surface, where the air and moisture are seen to resolve the rocks into loose sandy soils by gradually disintegrating the surfaces. In a similar manner the hard boiler incrustations are turned into a loose sediment like mud which is easily removed.

RED STAR BOILER COMPOUND AND PERFECTION BOILER COMPOUND FEEDER.

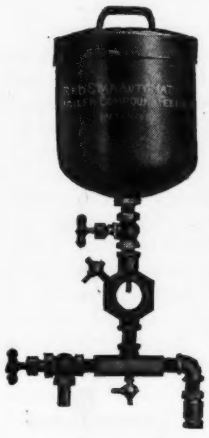
Lake Erie Boiler Compound Co., Buffalo, N. Y.

This compound is put up for the convenience of users, either in liquid or concentrated form. The liquid form is shipped in steel drums, giving a clean package to handle and preventing leaks. The concentrated form is put up in 5 lb. sacks or cartons, or packed in cases or barrels.

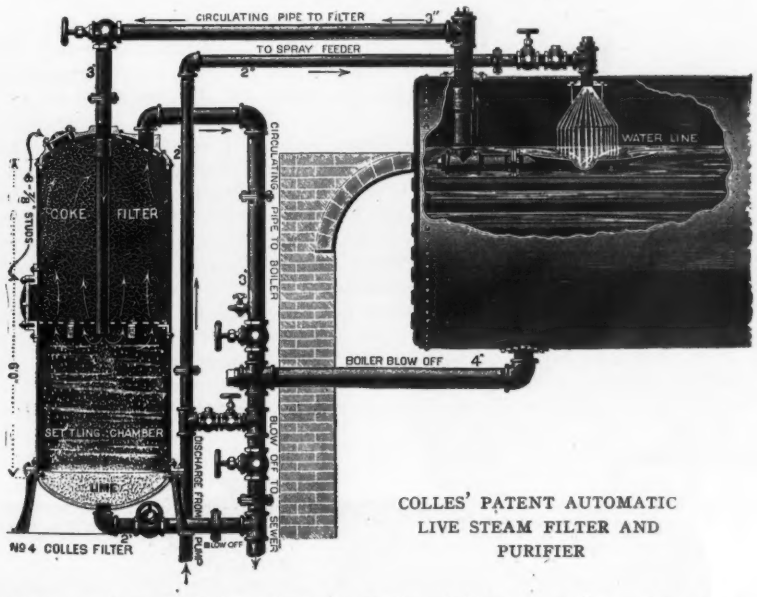
The Perfection compound feeder was patented by

the manufacturers and is loaned free to their customers to show the saving which can be made by the proper use of boiler compound in connection with this device.

It consists of a 2-gal. tank, made out of pressed steel with a cover and having at the bottom a finely perforated false plate, which acts as a strainer. Below this tank is a globe valve which regulates the flow of the compound. The drops or small stream of compound pass through a sight feed consisting of cast-



PERFECTION COMPOUND FEEDER



COLLES' PATENT AUTOMATIC LIVE STEAM FILTER AND PURIFIER

iron body with brass rings holding a glass plate in place on each side. The feeding is done by means of an injector device made of iron with brass nozzles.

Connection is made from the feeder to both sides of the boiler feed pump, that is, to suction and discharge lines. The angle valve side of the feeder is connected to the discharge line and the side with the check valve to the suction line, all joints being made absolutely tight. When connected, the tank is filled with compound, the angle valve adjusted so that the water does not back up into the sight feed glass and the feeder valve opened so that the compound feeds as needed. The water is, of course, taken from the pressure side of the pump, forced through the injector, carrying with it the charge of boiler compound and goes to the suction side of the pump, where it mixes with the main water supply.

PURIFICATION BY HEATING.

Heating and settling for the purpose of purification is a method quite commonly employed but usually in connection with the use of exhaust steam for the purpose of saving the heat in it. Heating with exhaust steam, if the temperature be raised to approximately 200 deg., will precipitate a considerable part of the carbonates, but if it is desired to take out the sulphates live steam must be used so as to bring the temperature up to 300 degrees.

After the high temperature has been attained, it is necessary to get the precipitated matter out of the water and this can be done by filtering, by settling, or by a crystallization process. The last named is the most frequently used. In this the water is divided into thin films so that the carbon dioxide may easily escape and in this way the carbonates are thrown out of solution and will be deposited on the surfaces over which the film of water is flowing. The purifiers are made of the open heater type so that the feed water and the steam used to heat it are mingled as intimately as possible. In some cases chemical reagents are used with these heaters, but not often.

To get good efficiency the important points to be observed are that the water shall flow slowly, that it shall be finely divided as a film rather than a spray, and that there shall be a chance for free escape of the carbon dioxide gas from the heater. In nearly all cases the purifiers which work by heating are also designed as feed-water heaters and will be described under the section devoted to open heaters.

COLLES PATENT AUTOMATIC LIVE STEAM FILTER AND PURIFIER.

E. G. T. Colles & Co., Chicago.

The apparatus shown here at the rear of the boiler may be placed on top or at any other location. It is designed to remove scum and scale-forming materials from the boiler and deposit them in a settling chamber from which they are blown out. It is cylindrical in form and has two compartments, the lower a quiet settling chamber for impurities, and the upper containing the filtering material. This purifier is made of boiler plate with top and side openings through which the filtering material is put in and removed.

The feed water enters the boiler over the spray feeder from which it falls into the receiver and passes into the settling chamber with the surface water, which is continuously skimmed by automatic circulation, gathering the impurities separated by evaporation, thence upward through the coke. The water thus purified returns to the boiler through the blowoff at the bottom, or it may re-enter through the front end of the boiler, or through the boiler shell on top. To wash the filter the water is reversed through it by opening the blowoff valve at the bottom of the purifier.

The Colles Co. also manufactures a live steam purifier and filter of the horizontal pan type.

PEERLESS BOILER CLEANSING COMPOUND.

The O. F. Zurn Co., Philadelphia, Pa.

It is a well known fact that scale is formed in a steam boiler by the crystallization of the impurities carried in solution in the feed water.

Absolutely pure water is not to be found in nature. Even rain water, which by the average layman is considered pure, contains substances, which from a chemist's point of view, are impurities. These impurities consist, to a great extent, of Carbonates of Lime and Magnesia, and also Sulphates of Lime, which are present in greater or less quantities. We mention these elements as they are the scale forming elements, and are the real source of scale trouble, although other impurities may exist in the same water.

Incrustation or formation of scale in a steam boiler is a more serious matter than is usually supposed. A water containing about 5 grains per gallon of solids or scale-forming elements will deposit a scale weighing 78 lb. per month for each 100 hp. running 10 hr. a day. Unless these deposits are treated in a scientific manner the results will prove most serious to the efficiency of the boiler. The effect of this scale formation not only injures the shell and tubes of the boiler, but will increase the consumption of fuel to a large extent.

To correct these evils it has always been the purpose of this company to begin at the real source of the trouble; to determine for each individual case the best treatment to pursue to obtain the best results.

With this object in view they apply the science of chemistry to the treatment of boiler scale, and manufacture a compound made up strictly in accordance with the individual requirements as shown by the chemical analysis of the feed water or boiler scale.

To manufacture a boiler cleansing compound, which must be effective in its results, is the work of skilled and competent chemists, who must apply their knowledge of the elements existing in the feed water, and construct a compound composed of such chemicals as are certain in their reaction.

The Peerless boiler cleansing compounds are manufactured under the direct supervision of practical chemists who are governed entirely by the results shown by the analysis of the sample of scale or water. They can therefore be used with perfect freedom, as being made by chemists, all materials of injurious character are guaranteed to be eliminated, so that all brass, iron and packing are free from attack.

BRISAM COMPOUND

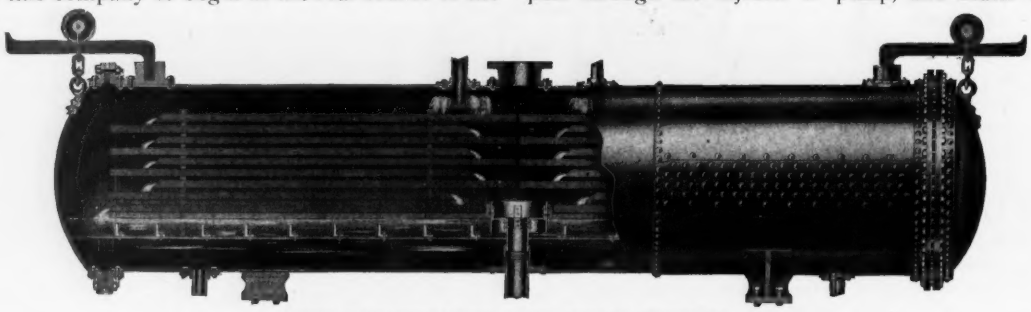
British American Chemical Co., Paterson, N. J.

The experience of this company in manufacturing and selling compound shows that the feeding of a large quantity of the solvent at one time, say every week, as is done when the compound is all dumped in after internal examination and cleaning of boilers, is bad practice. In the case of a boiler of 100 hp. evaporating 30 lb. of water per hp. hr., they find that no trace of the solvent is left after the first day's run, so that there is really but one day a week of treatment. The method employed to feed compound is a lubricator made especially for the purpose, which is arranged to feed continuously such a quantity as, after analysis of the feed water and the amount of scale formation before the use of the compound, is found necessary.

THE BIRD-ARCHER COMPOUND FEEDER

This is made in 2 forms, one for feeding large boilers, the other for small installations. Where the compound is introduced into hot wells, a 10-gal. tank is provided with sight glass, the compound being allowed to drop from a valve in the bottom into the well at the rate needed.

Where plants are large enough to require it, a small steam pump is arranged to draw the liquid compound from a 60-gal. tank, the mixing tank for the compound being placed above the feed tank. The pump draws solution from this tank, B, and discharges into the feed line to the boiler. For smaller plants, less than 1000 hp., an automatic cup is made, to be attached to the suction line so that the compound will pass through the injector or pump, and heater keeping this apparatus as well as the boiler free from scale. In attaching the cup, it is tapped into the suction line or a suitable tee added



THE BARAGWANATH LIVE STEAM PURIFIER

BARAGWANATH LIVE STEAM FEED WATER PURIFIER

Wm. Baragwanath & Son, Chicago

The live steam purifier is intended for use on very hard feed water containing a large proportion of scale-forming matter that requires a higher temperature for precipitation than can be reached with exhaust steam. A large amount of pan surface is provided for collecting the scale. These pans are of heavy steel with angle iron sides, and resting in angle iron brackets, and are so arranged that the feed water flows forward and backward several times the whole length before falling into the collecting reservoir below. The water inlets are sealed to prevent water hammer. A removable perforated false bottom provides a quiet settling chamber for collecting such scale matter as may have washed over the pans.

A single strand of asbestos rope is used to pack the machine-tongued and grooved joints between the removable heads and the shell.

The purifier should stand several feet above the water level of the boilers, the water flowing to the boilers by gravity. These purifiers are heavily built, being tested to 60 per cent higher pressure than carried by the boilers.

OIL FROM RETURNS

In order that condensed exhaust steam may be used to feed into boilers it is necessary that the oil which was used to lubricate the cylinder be entirely removed as this class of impurity is one of the most objectionable that is liable to get into a boiler. To accomplish this purpose oil separators, filters or a process of settling and skimming are employed, either singly or combined as the case demands.

Oil separators are made in numerous designs, nearly all of which are purely mechanical in operation and depend upon the fact that the entrained oil is heavier than the steam which carries it in a spray from the engine. For that reason when the path of the exhaust is suddenly diverted the greater momentum of the entrainment throws it out of the current of the steam, where it is caught and drained into a receiver.

There is another class of separators that rely upon the adhesive quality of oil to collect it from the steam, by placing a series of fine screens across the path, which catch the oil and drain it into a receiving reservoir.

Separators are divided into 2 types, horizontal and vertical, depending upon whether they are designed for use in horizontal or vertical exhaust steam pipe lines.

The filters used to remove oil from the returns or exhaust condensation are very similar to those employed in clarifying water of suspended matter, which have been described at length in another article.

In condensation that has been allowed to become quiet the oil will rise to the surface, where it can be removed by skimming.

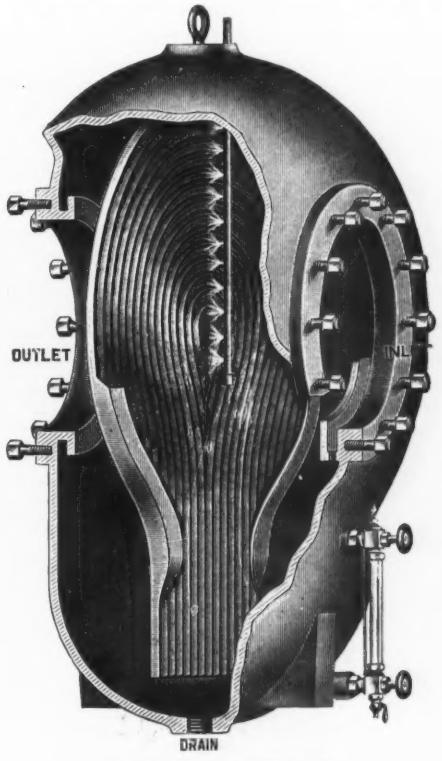
THE AUSTIN OIL SEPARATOR.

Austin Separator Co., Detroit, Mich.

This separator is characterized by a peculiar flat and oval design providing great internal area as a means of reducing temporarily, the velocity of the exhaust steam current. From experiment it was found that a large part of the oil in exhaust steam travels along the lower inner side of the pipe and to intercept this a flanged gutter is placed just inside the inlet to the separator. This catches the oil which is drained down into the receiver. The remaining oil and water are thrown against the baffle plate which is deeply corrugated with circular grooves leading to the receiver part of the separator. On the outside of the baffle is a high flange edge to prevent water or oil from rebounding over the sides.

The baffle is so located as to afford relief for the steam passing completely around it thus avoiding any back pressure in the separator. To catch any oil that might adhere to the surface of the separator, a ring flange is provided at the point of outlet.

For separators that are to be used in an exhaust line carrying high vacuum, the Austin Company has discovered that successful operation depends largely upon keeping the baffle plate and inside walls moist. If these are dry, the oil seems to be repelled from the dry surface and is carried along with the steam into the condenser and thence into the feed water. If the inside of the separating chamber is wet, the oily particles adhere and accumulate until they are thrown by gravity to the bottom of the chamber. The drop in pressure at the end of the stroke in a condensing engine is so great that the moisture in the steam is largely evaporated and to secure the thorough wetting of the separator walls a spraying device is used which throws water directly on the face of the baffle plate, thus effectively wetting and cooling it. The



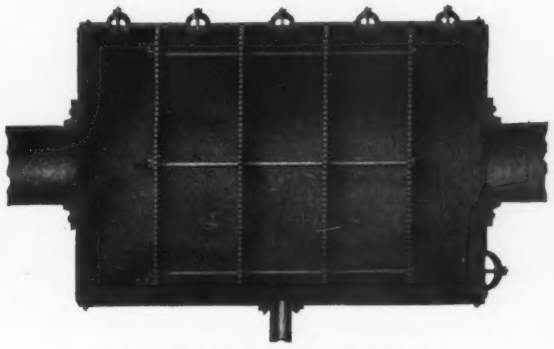
AUSTIN OIL SEPARATOR

arrangement of this baffle plate and spray which are covered by patent is shown in the sectional view of the Austin separator.

BARAGWANATH OIL SEPARATOR.

Wm. Baragwanath & Son, Chicago, Ill.

As arranged for oil, this separator takes the steam at the center of one end and discharges it at the center of the other end. Perforated plates are provided having ample area for the steam passages and an abundance of surface for the collection of oil. The water



BARAGWANATH OIL SEPARATOR

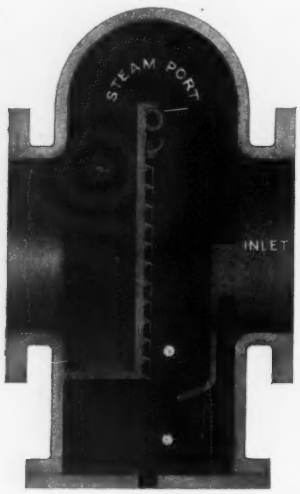
and oil are drawn from a drip at the bottom of the tank and hand plates are provided so that each side of each baffle plate can be washed off if it becomes

foul. A water glass is furnished with each separator to show the level of the oil and water. The shell and heads are made of ¼-in. steel plate with cast-iron flanges riveted to the ends for the connection of inlet and outlet pipes.

THE CRANE CO. OIL SEPARATORS.

The Crane Co., Chicago.

These have been carefully designed to give a large baffle surface and large internal area so that the velocity of flow of the steam will be decreased rather



THE CRANE CO. OIL SEPARATOR

than increased. They are also arranged so that the baffle can be cleaned as this is absolutely necessary to keep up the efficiency of the separator. For vacuum separators are arranged for drawing off the oil without decreasing the vacuum by means of an oil pump. A spraying surface device is also employed to keep the surface of the baffle plate wet. For the larger sizes of the separators a system has been devised whereby the baffle plates may be cleaned by pumping a solution over the baffle plate to disolve the coating which may form. A pocket is provided on the inlet side of the separator to catch any steam or oil that may run along the lower side of the pipe in a horizontal line.

SWEET SEPARATOR

The Direct Separator Co., Syracuse, N. Y.

Where oil of a proper grade is used, it appears in the exhaust steam as an emulsion with the water particles so that the requirement for separation is the same as removing water from steam. In noncondensing lines the regular steam separator is used. The Sweet separator was developed by a long series of experiments and acts by passing the steam over a corrugated or rough surface to which the little particles of oil and water adhere. This surface is so perforated that the little particles of water are immediately conducted out of the steam current, and in order to secure great efficiency a liberal area of separating space is allowed, a large space for steam storage, and a water chamber.

In the vertical style as shown the steam and oil separate upon a conical surface which is covered with a perforated copper plate through which water may readily pass, but through which it cannot readily escape. Water thus collected is carried by the conductor pipe to the receiver, the steam passing on in an annular ring comes in contact with the lining of the shell, which is a surface of the same character as that of B, and which catches and removes the water, draining it into a trough at the bottom.

The direction of the current of the steam is reversed twice, bringing it upward and again downward into the outlet pipe. The design is arranged to prevent contact of any of the water with the steam current after sepa-

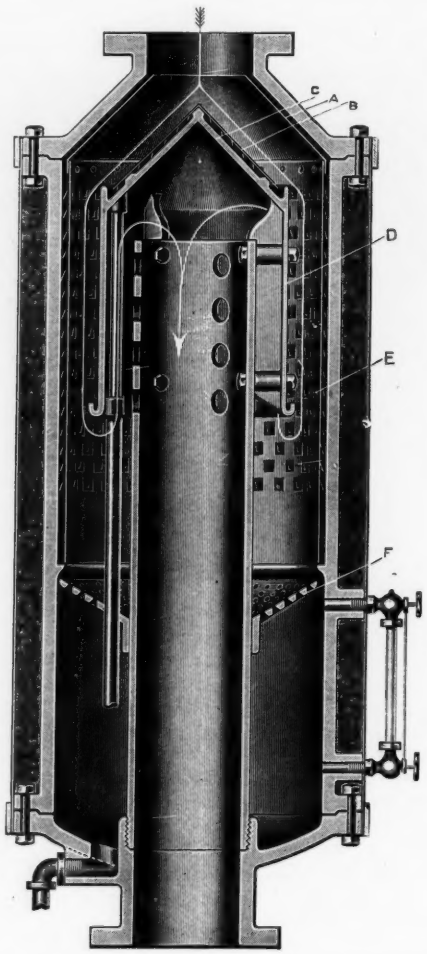


FIG. 1. VERTICAL STYLE SWEET SEPARATOR

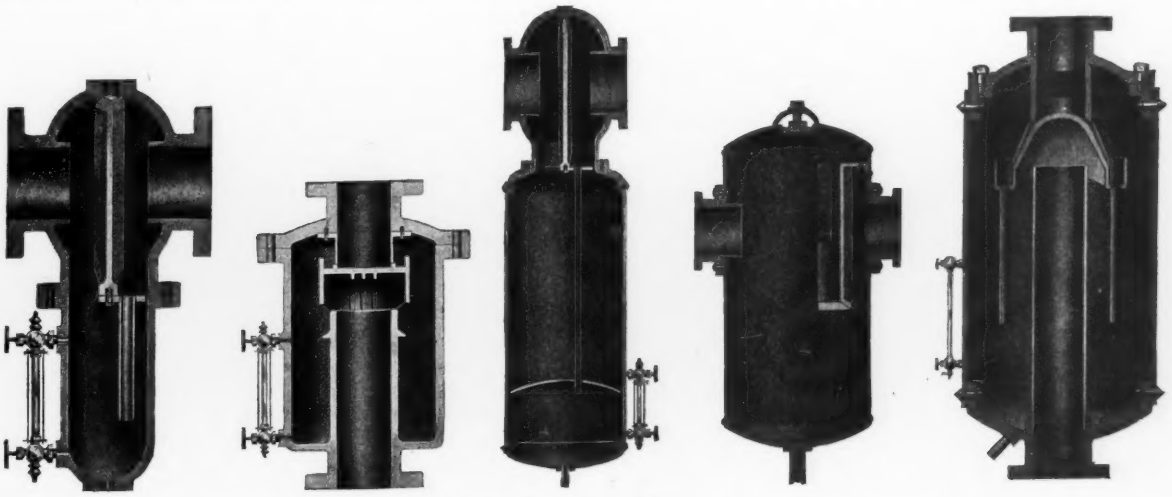
ration once takes place, and the whip-snapping action precipitates the moisture which is heavier than steam to the water chamber.

In the horizontal separator the action is the same, but the arrangement of parts is slightly different. When used for a vacuum system, as a pound of steam at 27 in. vacuum occupies about 7 times what it does at the 1 lb., it is necessary greatly to reduce the velocity of the steam, and the separating surface and area of the separator are therefore enormously increased. Each separator is designed very carefully to fit the condition under which it is to operate after knowing the number of pounds of steam that is to be handled and the pressure in the exhaust line.

THE ECLIPSE SEPARATORS.

The John Davis Co., Chicago, Ill.

These separators are designed and used to remove condensation, oil and other matter from the steam, either live or exhaust. Oil in the exhaust is bad for the boilers, if you condense the steam and use it over again, as the oil settles on the bottom of the boilers and causes the crown sheet to be damaged.



ECLIPSE SEPARATORS

The Eclipse separators, horizontal type, Fig. 1, are designed so that steam entering the separator strikes the baffle plate, the condensation or oil passes to the receiver at the bottom and the dry steam passes around and does not come in contact with the separated oil or condensation. The separators are designed with a view of obtaining as large a baffle surface and internal area as necessary, and to decrease the velocity of the steam.

In the vertical type, Fig. 2, the steam passes up or down and comes in contact with the baffle plate and the same results are obtained as in the horizontal. The receiver pattern separators horizontal, Fig. 3 and 4, and the vertical Fig. 5, being a few of several styles in which they are made, are designed and are intended to be used in the live steam pipe as near the throttle of the engine as possible not only to provide dry steam but to act as a cushion on which the blow from the cut-off in the steam chest may be spent and preventing vibrations from being transmitted through the piping system. It will also supply full amount of steam to the engine and will furnish a steady flow of steam and make up the loss caused during the first quarter of the stroke.

These separators are generally used in connection with a steam trap which automatically relieves them of the condensation or oil.

COCHRANE SEPARATOR

Harrison Safety Boiler Works, Philadelphia, Pa.

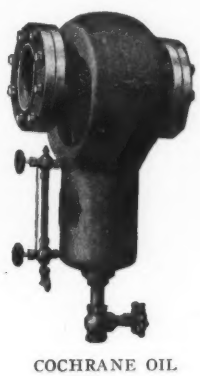
Cochrane separators contain a single vertically ribbed baffle placed directly in the path of the entering steam which impinges against it; this allows the oil or water to drop out and the steam passes around the sides of the baffle in a purified condition. The downward flow of the removed liquid into the well is not obstructed or retarded in the slightest manner. The ribs are well proportioned and the passage under the baffle closed to prevent the subsequent picking up of the removed particles.

Efficient results are obtained and the possibility of the separator creating back pressure is eliminated since the area of the steam ports on the sides of baffle is made considerably larger than that of the pipe itself. The design of the vertical separators for both ascending and descending current work is a baffle construction similar to the horizontal type, and equally efficient results are obtainable.

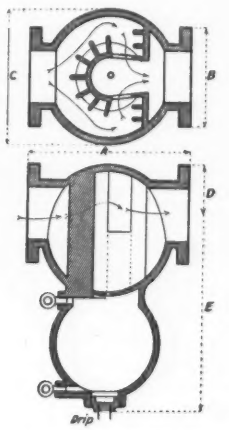
THE BAUM SEPARATOR

Hershey Machine & Foundry Co., Manheim, Pa.

By the use of a corrugated baffle plate the incoming current is split, throwing the steam to the sides of the separator chamber so that immediate separation of the water and oil from the steam is secured, and permanent isolation. By the shape of the baffle plate, no sharp angles are to be turned by the steam, and no energy is expended in throwing out the particles of water and oil, nor can any of the liquid splash back into the current. When used on a vacuum line, the design is changed so that the



COCHRANE OIL SEPARATOR



THE BAUM SEPARATOR

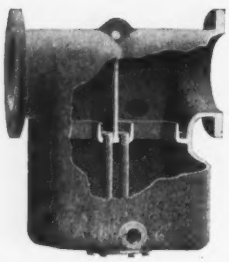
baffle plate is cooled by water circulation, an oil trap is introduced at the inlet in front of the baffle plate surface and the area of the separator is increased.

HOPPES OIL ELIMINATORS

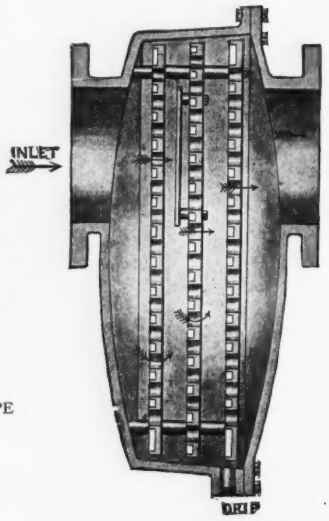
Hoppes Mfg. Co., Springfield, O.

In the Hoppes oil eliminator, horizontal, cast iron type of which is shown in cut, the designer has given particular attention to means for thoroughly eliminating the oil and water without causing back pressure or reducing the vacuum. There are no restricted passages, as nowhere are the interior chambers of working parts less than 1½ times the area of the ports.

It has frequently been proven by test and experiment that by far the greater part of the oil in an exhaust steam



HOPPES HORIZONTAL TYPE OIL ELIMINATOR



KIELEY MULTITUBULAR OIL AND GREASE EXTRACTOR

current is thrown to the outside of it, and forming an entrainment on the interior surface of the pipe, creeps slowly along in the direction of the steam current. This entrainment is well taken care of in Hoppes eliminators by troughs partly filled with water, which guard both inlet and outlet ports, entirely intercepting the creeping oil and water, and conducting it to the bottom of the eliminator by means of drain pipes, whence it is trapped off in the usual manner. Any oil, however, which may be atomized and carried along with the steam, not being caught by the trough at the inlet, in the rush of the steam through the eliminator, is cast upon the surface of the water in the bottom of the receiver chamber and there retained. The intercepting trough surrounding the outlet is a further safeguard against any possible additional creep of entrainment.

Hoppes eliminators are built in cast iron construction of horizontal and vertical types for all sizes of steam pipes, and in steel shell construction in all sizes and types to suit conditions and requirements.

KIELEY MULTITUBULAR OIL AND GREASE EXTRACTOR.

Kieley & Mueller, New York.

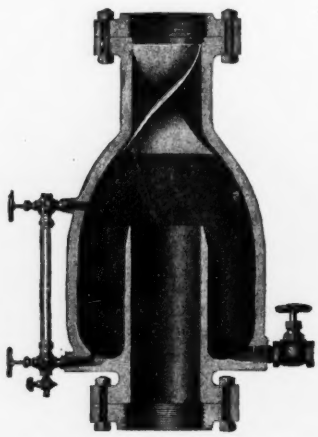
Mounted on a plate which separates the head of the separator from the receiver tank is a series of tubes having one side open. As the steam enters the separator, it strikes against the open sides of the tubes and the oil and water deposited on the inner surfaces of these tubes flow downward through perforations in the plates to the receiver tank. The steam flows by the tubes and passes on to the separator outlet. By this arrangement, a large effective baffling is secured with a minimum of drop in pressure.

In the Kieley 1906 oil and grease extractor the steam is passed through a series of perforated plates having grooves between the perforations and having the perforations set staggered in the different plates so that the steam must take a zig-zag course, and the oil and the water will be caught in the grooves and conducted to the bottom of the separator chamber and out from the drip pipe.

SWARTWOUT STEAM AND OIL SEPARATOR

Ohio Blower Co., Cleveland, O.

The principle of centrifugal force is made use of in the construction of this separator, a helical-shaped deflecting plate being placed at the mouth of the separator. The steam because of its high velocity passes in a whirling cylindrical stream directly from the entrance to the exit pipe. It is so light that centrifugal force has little effect upon it, but the heavy entrained water and oil are by the same whirling action of the helix thrown outside the limit of this column and fall into the annular cham-



SWARTWOUT STEAM AND OIL SEPARATOR

ber which forms the lower portion of the separator. Thence it is readily drained through the drip pipe, the interior level being shown by the gage glass. One distinct advantage claimed for this separator is that no reduction in steam pressure is effected by its passage through the separator.

THE WEBSTER SEPARATOR.

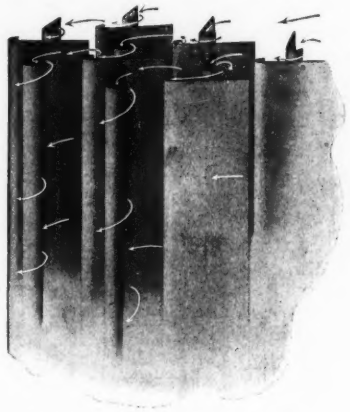
Warren Webster & Co., Camden, N. J.

Three classes of these separators are made, horizontal, vertical or special, for either condensing or noncondensing service. All of these work upon practically the same principle, which is illustrated in Fig. 1.

The operating principle is a combination of centrifugal force, adhesion and the impact of particles of oil and moisture against the baffles at right angles to the flow of steam as will be noted. By this method the steam can follow the zig-zag course through the

separator without material loss of pressure and the particles of oil and moisture are caught on the surfaces of the baffles and flow down through suitable openings in the floor of the baffle section into the receiver below.

For condensing service the separator is provided



ARRANGEMENT OF BAFFLES

with a larger receiving well, drained by means of 1 of the 2 following methods:

The separator may be connected directly to a receiving tank through a valved pipe. An equalizing

THE WEBSTER SEPARATOR

pipe is connected from the tank to the condenser, thus equalizing the pressure between the two. As soon as the drip accumulates to a point where the tank should be emptied, the sink pan (performing the functions of a float) placed within the tank, rises and operates a series of levers which cause the whistle to give an alarm to the engineer, who closes the valve in the drain pipe from the separator and the valve on the equalizing pipe and opens the steaming out valve and the tank drain. The contents will then pass from the tank to the receptacle provided for such oily drip, or to waste.

The other method is automatic, doing away with the necessity for a receiving tank and occasioning no loss of vacuum in the main condenser through the use of this apparatus.

A counterbalanced sink pan is placed within the separator well at the required height and connected through stuffing box and gland to a series of levers on the outside for the operation of a steam valve to a small pump. Accumulations within the separator well flow to the pump by gravity and, upon the pan within rising, the steam valve opens and starts the pump into operation. The oil drip is discharged into a small receiver placed above the separator and thence into a small open receptacle at the floor level, the pipe entering same below the liquid, being sealed. From this receptacle it overflows to waste. A connection is made from the small receiver mentioned to the separator to equalize the pressure.

Separators for noncondensing conditions may be drained either by means of the ordinary vented seal or by means of a Webster Grease Trap, made especially for this service.

THE SIMS OIL EXTRACTOR

The Sims Co., Erie, Pa

This device is used where it is important to remove grease from the exhaust steam, as in the case where it is required for open feed water heaters and the like. Exhaust steam enters the separator through the pipe

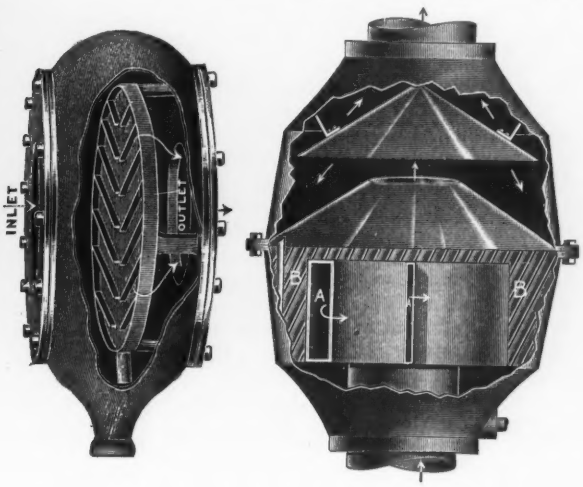


FIG. 1. HORIZONTAL TYPE SIMS SEPARATOR

FIG. 2. VERTICAL TYPE SIMS SEPARATOR

at the bottom and is given a whirling motion as it enters the separating chamber through the ports A. By this motion the entrained oil and water are thrown to the corrugated sides and drained to the receiver below. The steam rising, passes through the opening at the top of a cone-shaped partition, strikes the de-

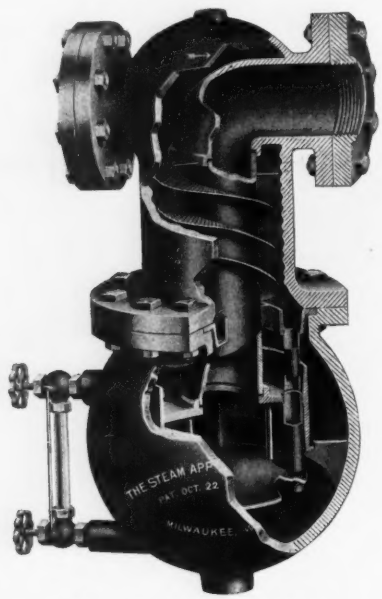
flector and passes around its edges and out at the top of the separator.

This company also manufactures a horizontal oil separator which works on the same principle.

TRIUMPH OIL SEPARATOR

The Steam Appliance Co., Milwaukee, Wis.

Exhaust steam entering this separator, as shown in the illustration, is directed downward in a spiral



TRIUMPH OIL SEPARATOR

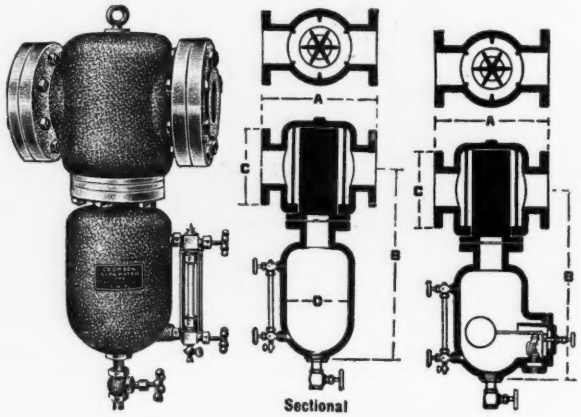
path, thus throwing the entrained water and oil to the sides of the separator from which it is washed by the hot water of condensation into the 2 annular catch basins, from which it is drained through the spreader or lower baffle to the receiving chamber at the bottom. The steam passes between these 2 catch basins and then is given a quick reverse motion in the lower part of the separator, passing upward and is exhausted through the pipe in the center and out on the right side through the inner elbow. The entrainment is drained from the separator by the pipe at the bottom, and the gage glass shows that the separator is free from accumulations, as no entrainment should be permitted to stay in the separator body. This type of separator is self-cleaning and will perform efficient service either under pressure or vacuum if of proper size and properly drained.

THE COOKSON SEPARATOR.

The D. T. Williams Valve Co., Cincinnati, Ohio.

Steam entering this separator is divided, an equal amount passing on each side of the star baffle plate. Striking into the angle of the star the steam is thrown back against the shell, then reversed into the second angle of the star, again flows back to the shell and after a third double reversal passes to the outlet. The water and oil are caught on the surfaces of the star baffle and of the shell of the separator, and conveyed through openings into the well at the bottom. The special feature of this separator is that it can be taken apart without breaking the steam piping. By removing the bolts the bowl comes off, when the star baffle can be removed, leaving the entire inside of the head of the separator accessible. This makes it possible to give the entire apparatus a thorough cleaning, which is absolutely necessary in order to make an oil separator efficient.

This company also manufactures a separator known as the Cookson horizontal automatic separator, which is essentially a separator and steam trap combined. With this apparatus, the entrainment is auto-



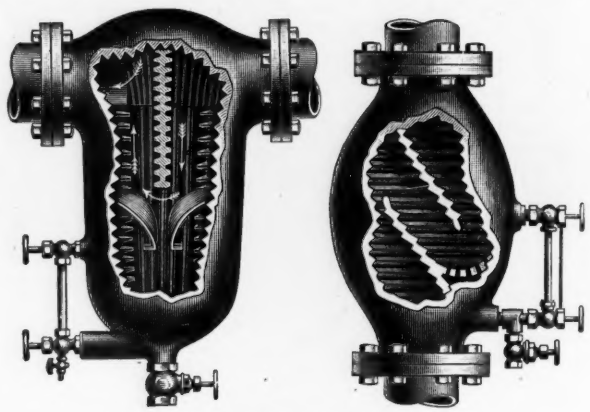
THE COOKSON SEPARATOR
COOKSON AUTOMATIC SEPARATOR

matically discharged from the receiver and requires no attention on the part of the engineer.

THE HINE ELIMINATOR

Jas. L. Robertson & Sons, New York.

Exhaust steam on entering this oil separator impinges the corrugated surfaces which are placed at proper angles to carry the water and oil to the reservoir at the bottom without again coming in contact



HORIZONTAL TYPE HINE ELIMINATOR
VERTICAL TYPE HINE ELIMINATOR

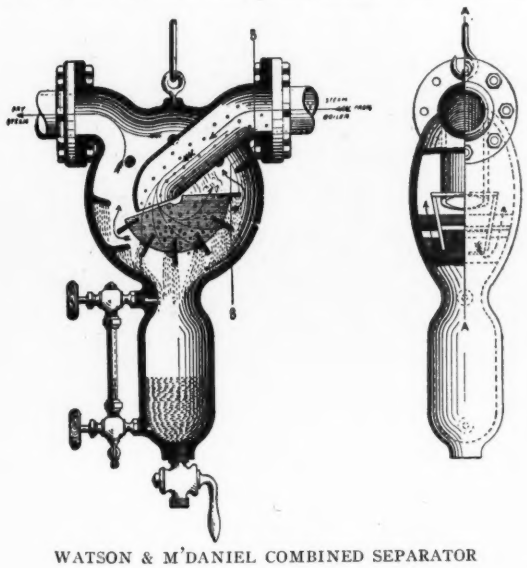
with the steam. Large area for expansion of steam on entering has been provided, thus eliminating the loss from back pressure.

Vertical oil separators are manufactured by this company which operate upon the same principle as its horizontal type. In both types of separators special attention has been given to the design of the reservoir, which is made deep and of large capacity.

WATSON & McDANIEL COMBINED SEPARATOR.

Watson & McDaniel Co., Philadelphia, Pa.

Steam entering this separator is given a whirling motion in the body of the separator which throws the entrained water and oil against baffle plates and to the sides of the chamber, from which it is drained to



WATSON & M'DANIEL COMBINED SEPARATOR

the well below. The steam thus relieved of the impurities leaves the separator at the outlet. The sectional views here illustrated, show clearly the construction.

LOEW OIL SEPARATOR.

Loew Mfg. Co., Cleveland, Ohio.

The feature of greatest importance and distinction in the Loew oil separator is the construction of the baffle bars, for separating oil from the exhaust steam, of which there are 3. These baffle bars are so placed

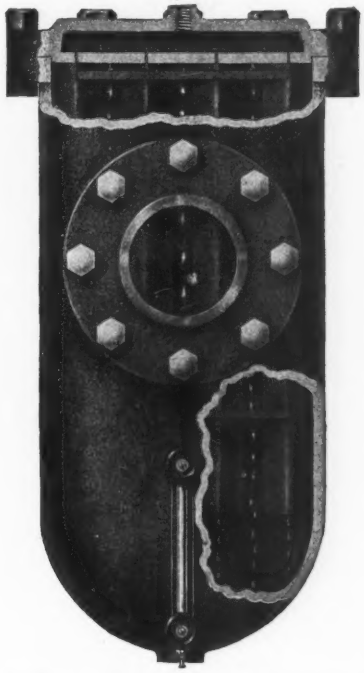
LOEW OIL SEPARATOR

as to permit giving the exhaust steam 3 treatments during its passage through the separator. The peculiar construction of the bar itself provides not only for retaining the oil after being separated but by means of the incoming steam forces the drops down the protected passage to the opening at the bottom of the bar, through which it passes into the receiver of the separator, out of the way of the current of steam. Thus the separator is self-cleaned and there is no danger of clogging the passage.

THE LIBERTY-GREENAWAY OIL SEPARATOR

Liberty Mfg. Co., Pittsburg, Pa.

This oil separator is designed to provide large areas, unrestricted passages, facilities for cleaning without breaking pipe connections and means for holding wet surfaces, combined with the feature of utilizing gravity as a separating medium.



LIBERTY GREENAWAY OIL SEPARATOR

Exhaust steam entering the separator on the side, impinges against the wet plates and is deflected twice before it can escape from the opposite side. This brings every particle of steam in contact with the surfaces of the deflecting plates. These plates are maintained moist by water spray dripping down their surfaces, thus causing the oil to precipitate upon the plates. Owing to the peculiar location and the forms of these plates, the oil cannot follow the steam in its circuitous force; therefore, it drips down the sides of the plates by gravity into the receiving chamber where it can readily be trapped away.

The water enters through a connection at the top of the separator. The entire interior of the separator is made accessible by the removal of the top, so that the plates can be taken out when necessary for cleaning.

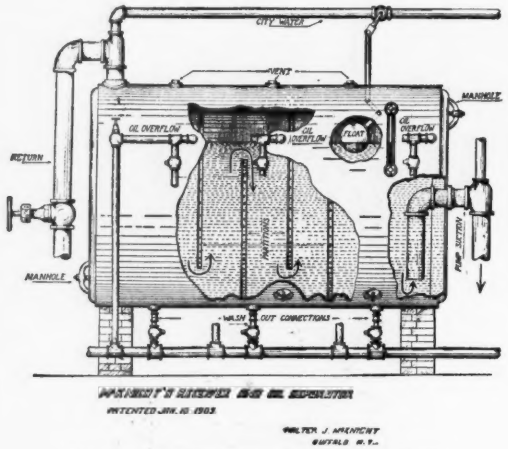
McKNIGHT RECEIVER AND OIL SEPARATOR.

Walter J. McKnight, Buffalo, N. Y.

The McKnight receiver and oil separator, as shown in the accompanying illustration, is to be used in connection with heating systems for running the returns back to the boilers. It does not take the cylinder oil

out of the exhaust steam in the usual manner in which it is generally done.

After the steam has passed through the heating system it returns to the basement and flows into the receiver tank, which has been previously filled with fresh water. As the exhaust steam is condensed back into water, the cylinder oil has also returned to its original state and as oil will float on the top of the water it flows out of the tank through the oil over-



MCKNIGHT RECEIVER AND SEPARATOR

flow pipes. The action of condensed water in the receiver is down 1 partition and over the other partition, and so on, during which time the oil separates from the water and by the time it gets to the pump suction pipe nothing but pure water remains.

As will be noticed, there is a float connected to the city water line which admits water according to the amount of leakage in the system. In case the water should become shut off or the float disabled, the pump is prevented from pumping the receiver empty, because when the water level drops to the centre of the T in suction pipe, the pump will get air through the top of suction, instead of water through the bottom.

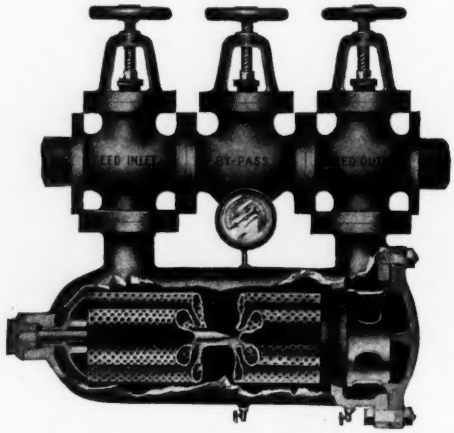
Should the cylinder oil become heavy with sediment it will sink to the bottom, the same as it would in a boiler, but the natural flow of the water in the tank will cause it to flow down under one partition and over the other partition, so that it will come to the surface again and will be drained away as before.

REILLY OIL AND GREASE EXTRACTOR

Griscom-Spencer Co., New York.

After exhaust steam has condensed, the oil which was vaporized, again becomes a liquid, and may be filtered out. Based upon this principle of the extraction of oil, the Reilly oil and grease extractor has been designed. This is an apparatus consisting of a cast-iron body in which there is a corrugated sheet metal cartridge, shown in the illustration given. This cartridge is perforated, and it is covered with heavy filtering cloth, so that the water coming in through the by-pass valves enters the body, surrounding the cartridge, and filters through the cloth. A very large filtering area is provided for, so that the action of the grease extractor is efficient. One end of the cartridge is closed completely, and the other end is fitted to a casting like a valve disk, which rests upon and closes the end of the body. By removing a few bolts in the head of this cartridge, it may be taken out, the filtering cloth removed and a fresh cloth drawn on, the soiled cloth being washed at the convenience of the engineer.

The by-pass valves are arranged so that they may be changed without interfering with the feed to the



REILLY OIL AND GREASE EXTRACTOR

boiler, and the labor required for the change is very small.

THE AMERICAN SEPARATOR

The Whitlock Coil Pipe Co., Hartford, Conn.

A bridge partially divides the inner space of the separator head into an upper and a lower chamber. A vertical wall of the same width reaches from the diaphragm or bridge to the top of this chamber. From the two sides of this wall, baffle plates extend towards the inlet and outlet, forming 6 pockets which catch the particles of

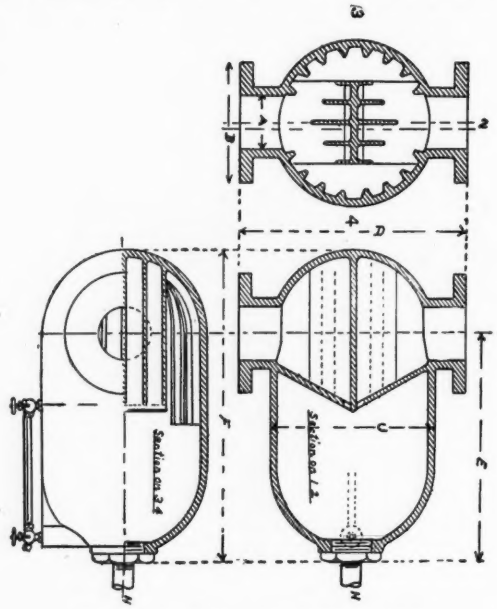


FIG. 1. THE AMERICAN SEPARATOR

water and oil where they cannot be mixed up again with the steam, but are drained into the receiver chamber below. Ribs on the outside wall of the separator head assist also in the removal of the oil and the moisture.

BLOWING DOWN

No matter how much care and pains are taken to remove all impurities from feed water before it is pumped into the boiler more or less sediment will collect there which, though it may not be dangerous or destructive, if allowed to accumulate to any extent, will greatly reduce the efficiency of the boiler.

Every boiler is therefore provided with an efficient means for blowing off the sediment that settles to the bottom. While this means of removing objectionable matter from boilers is comparatively simple so far as it goes, the difficulties which have presented themselves have given rise to the design and manufacture of a large variety of special blowoff valves. The severe wear and cutting effect to which a valve used for this purpose is necessarily submitted, demand that extra provision be made to secure a valve that will not leak or give way under heavy pressure, high temperature and wearing effects of sediment and boiler scale flowing at a high velocity.

Great care should be exercised in blowing off a boiler for accidents frequently occur owing to the shifting of the sediment, causing the boiler tubes or plates to become suddenly cooled and cracked. Many authorities advise that blowing down should be done only when there is no fire under the boiler, though if care is taken to keep the sediment from accumulating to any extent and the fire allowed to become low a boiler can be blown down without any great danger.

The frequency with which boilers should be cleaned in this way depends almost entirely upon the quality of water used, though in no case should the sludge be allowed to remain so long as to become baked or harden in the blowoff pipe. While the time intervening between blowing off can therefore not be stated definitely, it is well to see that the blowoff valve is opened at least once a day and in many cases every few hours. A good plan is to blow down the boiler before starting up in the morning and at those periods of the day when the load is light and the fires banked. If the blowoff valve is opened when heavy pressure is on the boiler, the rush of water through the pipe does not allow the sediment to drain from the full surface of the bottom and for that reason this is a very unsatisfactory time.

To clean the blowoff pipe properly the valve must be opened wide, if only for a few seconds, to allow the sediment which has collected around the seat and disk to be washed off completely. The amount to be discharged each time also depends upon the quality of the feed water, the only guide being the color of the discharge or experience in the individual plant.

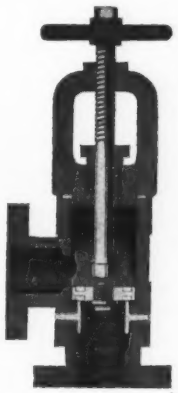
Blowoff valves should never be opened and closed suddenly, as the surging of water in the boiler or the water hammer which results place the boiler under very severe strains and frequently cause explosions. Suddenly closing the valve may cause the blowoff pipe to be stripped of threading, resulting in dangerous accidents to the operator.

CADMAN'S INDESTRUCTIBLE BLOW-OFF VALVES

A. W. Cadman Mfg. Co., Pittsburg, Pa.

Cadman's indestructible blow-off valve, shown in the illustration, is of the outside yoke and screw pattern, and being of the angle type, retards the flow of the stream across the disk and seat, thus preventing excessive wear of these parts.

The disk is a brass bound solid copper plate which can be reversed or refaced in an ordinary lathe until it is too thin for further use. The seat is a hard phosphor bronze tube, with similar faces on either end, so that when one face is cut or worn, it can be reversed and the other face used. Both ends can be refaced a number of times, thus making practically 2 valves in 1. A peculiar feature of the type of seat is a projecting flange which is clamped between the valve body and the base and which prevents leakage past the seat, making it convenient to get at for reversal or refacing without removing the body from its position.



CADMAN'S INDESTRUCTIBLE BLOW-OFF VALVE

ECLIPSE REGRINDING BLOWOFF VALVE

THE ECLIPSE REGRINDING BLOWOFF VALVE.

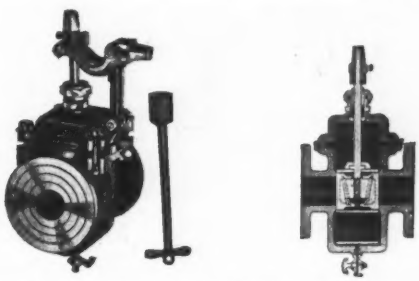
The John Davis Co., Chicago.

This valve is made so that the pressure is always against the disk, forcing it against the seat. The stem and disk are in one solid piece of bronze which is so threaded that the valve can be reground with full boiler pressure upon it. The parts of the valve can be easily replaced.

WATSON & McDANIEL STRAIGHTWAY BLOWOFF VALVE.

Watson & McDaniel Co., Philadelphia, Pa.

This form of valve has a straightway cylindrical port through the valve. The seats are covered when the valve is open and thus protected against injury when the valve is in operation. To open the valve a socket wrench is used to turn the valve stem to the left, which releases the disks, then the wrench is used



WATSON & M'DANIEL STRAIGHTWAY BLOWOFF VALVE

to work the lever to throw the cage over and bring the ports into line. The reverse of this operation closes the valve, force enough being used to close it tightly, which will lock it securely. These valves are now made from new patterns, and all sizes are extra heavy, good up to 200 lb. steam pressure.

FABER BLOW-OFF VALVE

Liberty Mfg. Co., Pittsburg, Pa.

This blowoff valve is provided with a means for cleansing the disk and seat by a jet of steam or pure water after the water is practically shut off but before the valve is finally closed.

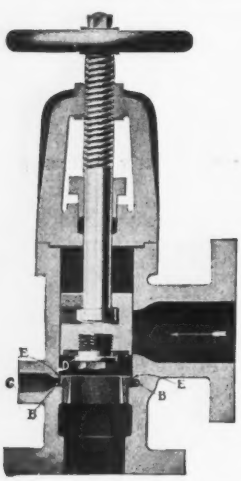
When the disk, which makes a snug fit in the body of the valve, is in the position shown in the illustration, the water is practically shut off and the sediment lying on the seat at this instant would remain there were not means provided for its removal. Surrounding this seat A is a chamber B into which steam is introduced at full boiler pressure, through a ½-in. connection, C, which leads from the steam main. The outside diameter of the seat A is 1-16 in. smaller than the bore of the valve. A 1-32-in. opening, E, all around the seat is thus formed through which steam escapes from the chamber B and impinges on the disk and seat and thoroughly cleanses them from sediment.

To move the disk from position shown down to the seat requires 3 turns of the wheel, which allows time for the steam to perform its work of cleaning, and when the valve finally closes the seat and disk are as clean as though steam only were being used.

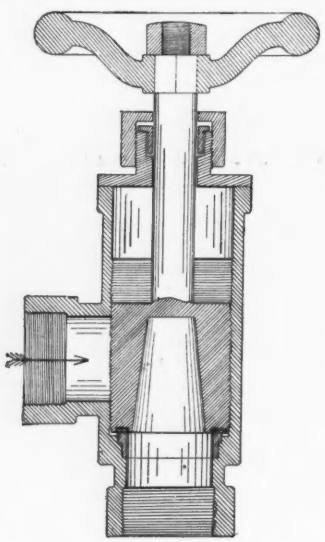
THE ERWOOD POSITIVE DUPLEX BLOWOFF VALVE.

John Erwood, Chicago.

This valve is designed to meet the severe service demanded of a blowoff valve on a steam boiler. The body is made of crucible steel and the plug of brass



FABER BLOW-OFF VALVE



ERWOOD DUPLEX BLOWOFF VALVE

which will not corrode or rust together. The plug is threaded into the body, and in being screwed down passes and shuts off the current from the inlet before the faces are seated. The inlet is on the side, as indicated by the arrow. As soon as the plug is screwed down past the inlet the current of the plug finally seats its face on the brass seat as shown; in this way the cutting effect of wire drawing on the valve and seat is eliminated.

The valve seat is of brass screwed into the body; the lip of the plug is grooved out and filled with steam metal and easily renewed by hand. The plug and stem are in one piece, hence, there is no chance of derangement from unscrewing of the threaded parts of the valve stem.

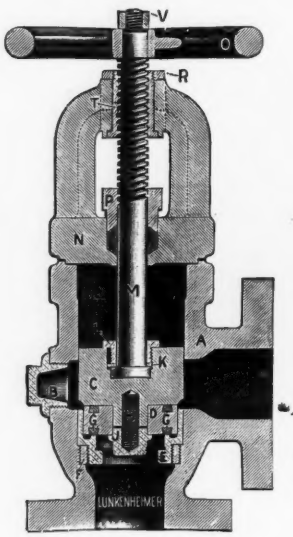
LUNKENHEIMER DURO BLOW-OFF VALVE

Lunkenheimer Co., Cincinnati, Ohio

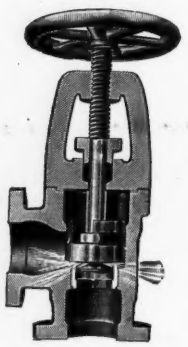
In this valve the plug fits snugly in a separate and easily removable bronze casting, which can be replaced when worn. Any accumulation of scale that might remain on the seat before the disk is brought into contact with it is washed off by the water which passes around the plug when seating.

In the sectional view it will be seen that the plug C carries a reversible double-faced disk D secured to the plug C by stud H and nut J. This plug is guided perfectly in the valve body A. The bronze seat ring E is screwed into a second bronze ring F, the object of this being to make it possible to renew the ring E easily in case it is worn. At the back of the valve is a plug, B, the use of which is to permit the introduction of a rod to clean out the inlet. The disk C is secured to the stem M by means of lock nut L. The stem operates in the bronze bushing located in the top of the yoke, which bushing can be renewed when worn and the stem and yoke are noncorrodible.

In closing the valve, the disk is screwed down in the usual manner and as it approaches the cylindrical extension of the seat ring E, any scale or sediment that might lodge between these parts is scraped off.



LUNKENHEIMER DURO BLOW-OFF VALVE



CLEAN-SEAT BLOW-OFF VALVE

When the part D of the disk has entered the seat extension a thin current of water passes around it, washing away any foreign matter that may have accumulated on the seat, the result of this being that when the disk is perfectly seated no scale or sediment remains between the bearings.

"CLEAN-SEAT" BLOW-OFF VALVE

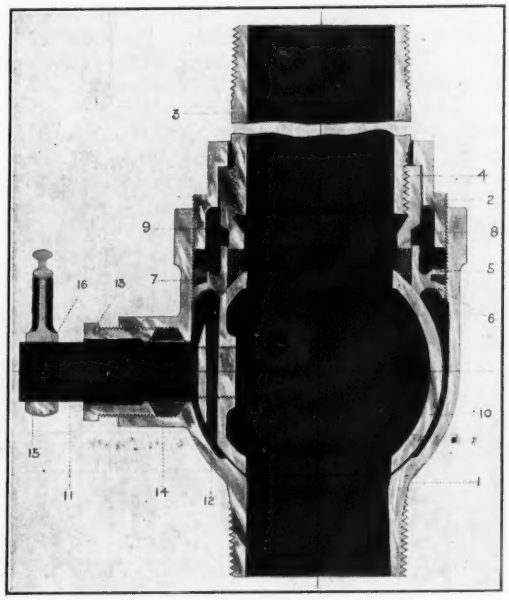
Pittsburg Gage & Supply Co., Pittsburg, Pa.

Having an iron body, the Clean-Seat blowoff valve shown in the illustration is fitted with renewable brass seat and disk. The disk piece has a slot which engages the T head on the stem, making a free connection and providing for easy removal in case it be desired. Simplicity, ample strength, good fitting, best materials and other features of mechanical excellence combine with the clean-seat principle to make this blowoff valve of merit. Its weight insures durability and safety, each Clean-Seat blowoff valve being tested to 500 lb. pressure; they are made either screwed or flanged, as desired. The operation of this valve will be understood from the cross sectional cut shown.

THE HUXLEY BLOW-OFF VALVE

Huxley Valve Co., Buffalo, N. Y.

This valve is made entirely of bronze with a full straight opening the size of the pipe from the boiler. The valve proper is a ball turning in a socket, the ball having a passage through it the full size of the pipe area. When closed, the spherical surface of the ball bears on the packing ring at the outlet, so that the higher the pressure, the tighter will be the joint.



HUXLEY BLOW-OFF VALVE

Packing is compressed by a screw similar to that on the stuffing-box of a valve or piston rod, and when the valve begins to leak, the packing may be tightened up by screwing up the cap nut.

These valves are made in sizes from ½ to 3 in. and will work on air, water or steam.

HOMESTEAD STRAIGHTWAY BLOWOFF VALVE.

Homestead Valve Mfg. Co., Pittsburg, Pa.

The cut shows the blowoff valve manufactured by this company which is also used for handling high pressures in either air, water, steam, etc. Its construction is similar to that of the standard straightway valve described elsewhere in this issue.

THE EVERLASTING BLOW-OFF VALVE

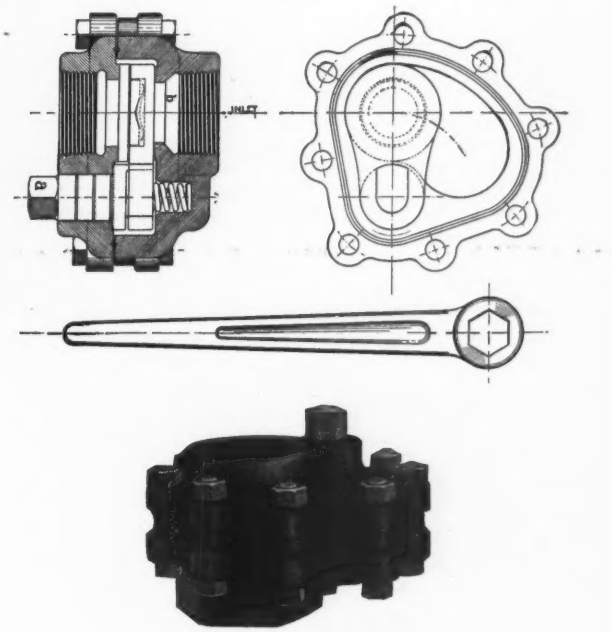
Patterson-Allen Engineering Co., New York

The valve here illustrated is composed of a top and bottom bonnet, a disk and a lever and post. To

HOMESTEAD STRAIGHTWAY BLOWOFF VALVE

operate the valve a wrench is placed upon the square head, A, and pushed down, opening it, and the reverse to close it.

The 2 bonnets are set together upon a high-pres-



EVERLASTING BLOW-OFF VALVE

sure gasket with machine bolts, giving quick access to the inside, should it ever be necessary to renew the disk or reface the seat. The operating post is set tight upon a ground joint and held there by a stiff drawn spring. It will be noticed that the inlet orifice is tapered just above the seat, at B. This increases the velocity of the blast at this point and insures its de-

livery into the discharge pipe without scoring the seat, as would be the case were this precaution not taken.

The Scully Steel and Iron Co. of Chicago handles the selling of the Everlasting blowoff valve for the central and western states.

THE BASHLIN BLOW-OFF VALVE

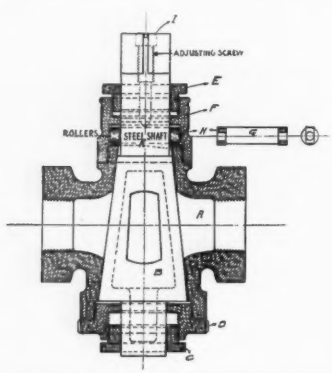
The Bashlin Co., Warren, Pa.

In the Bashlin blow-off valves both the vital parts, disk and seat, are renewable, the latter being replaced

BASHLIN BLOW-OFF VALVE

through the plug opening G. This renewable seat ring may be changed without blowing off; to do so, if installed with pressure on top of the disk, unscrew the plug G one complete turn or thread, again close the valve and push down the seat ring, J, lightly, unscrew the plug another thread and so continue until the valve is completely closed. Now remove the plug, place a new seat ring on post I, screw into the valve shell until the seat ring strikes the disk lightly, raise the stem and again screw up the plug lightly and so continue until the plug cannot be screwed up farther. The disk is renewed as in any other valve by removing the bonnet, and of course cannot be taken out under pressure, but since it is the seat which is more often damaged, the annoyance of changing disks is reduced greatly.

An important advantage of this construction lies in the possibility of using various materials for the seat



ANDERSON BALANCED BLOW-OFF VALVE

ring and ordinarily we have these rings in four materials, soft rubber composition for cold water, air and gas; asbestos-rubber composition or babbitt for moderate steam pressures, and copper for high pressures.

ANDERSON BALANCED PLUG BLOW-OFF VALVE

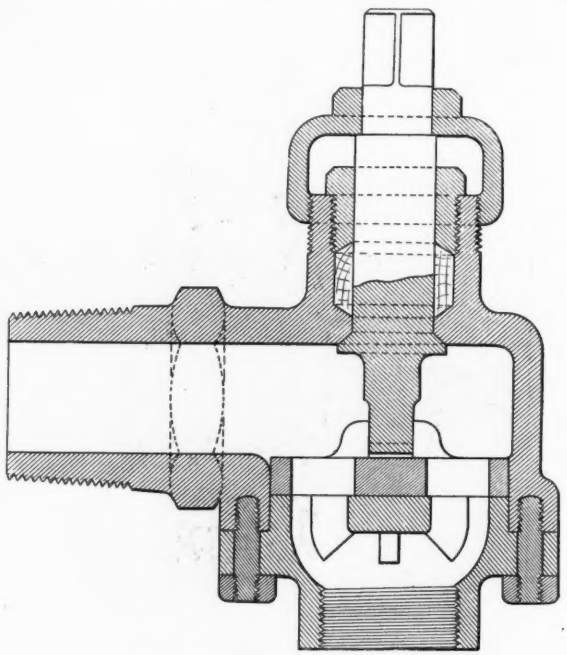
The Golden-Anderson Valve Specialty Co., Pittsburg, Pa.

This valve is constructed so that when the discharge under pressure passes through it the seating is protected from wear. The block is balanced and held in place by a patent roller rocking device which, combined with the pressure, insures freedom from friction in the closed or open position. When it is closed or open it is at the same time forced firmly to its seat. This result is secured by means of the roller traveling on inclined planes in either closing or opening. This feature is further safeguarded by the large packing gland with follower. The adjusting screw provided to take up all wear can also be securely locked in a closed or open position, as desired.

THE RIGGIN BLOWOFF VALVE

Monarch Machine Works, Altoona, Pa.

The Riggin valve has a brass body, at the upper side of which is a stuffingbox with screw gland fitting



THE RIGGIN BLOWOFF VALVE

into the inside and a lock nut screwing onto the outside of the box to hold the disk to its seat when filling a low-pressure boiler. At the bottom of the body a brass seat screws on, having large discharge area and 2 openings through which discharge takes place. The valve disk has 2 corresponding openings which may be turned either to match the openings of the valve seat or so that they are opposite the solid part of the valve seat. On the upper side of the disk are projections between which a T head on the valve spindle fits so as to turn the disk back and forth. The valve spindle passes through the stuffingbox and has at the upper end a square shank and also a shoulder against which the lock nut fits to hold the disk to its seat.

HEATING FEED WATER

FROM the early history of the steam engine the problem of saving the heat in exhaust steam has been one of continual study. Many ways have been devised to extract the heat from the exhaust, but the one which is most noteworthy and common in practice is that of heating boiler feed water by means of the exhaust. By this means it is evident that what heat is transferred from the exhaust to the feed water is clear gain and the percentage gain is therefore the difference in the temperature of the water entering and leaving the heater multiplied by 100 divided by the difference between the total heat of the steam, reckoned from zero, which is obtained by adding 32 to the value found in the steam tables corresponding to the pressure in the boiler, and the temperature of the feed water as it enters the heater.

PER CENT SAVING BY HEATING FEED WATER FOR 1 DEG. RISE IN TEMPERATURE

INITIAL TEMP.	BOILER PRESSURE						
	40	60	80	100	120	140	160	180
32	0.0855	0.0851	0.0847	0.0844	0.0841	0.0839	0.0837	0.0835
40	0.0861	0.0856	0.0853	0.0851	0.0847	0.0845	0.0843	0.0841
50	0.0868	0.0864	0.0861	0.0857	0.0854	0.0852	0.0850	0.0848
60	0.0876	0.0872	0.0867	0.0864	0.0862	0.0859	0.0856	0.0855
70	0.0884	0.0879	0.0875	0.0872	0.0869	0.0867	0.0864	0.0862
80	0.0891	0.0887	0.0883	0.0879	0.0877	0.0874	0.0872	0.0870
90	0.0902	0.0895	0.0888	0.0887	0.0884	0.0883	0.0879	0.0877
100	0.0908	0.0903	0.0899	0.0895	0.0892	0.0891	0.0887	0.0885

To take a specific example, if steam is generated under a pressure of 120 lb. gage the total amount of heat in 1 lb. of steam will be 1220.7 units and if the feed water is at 45 deg. when it enters the heater and leaves at 205 deg. the saving represented by these conditions is,—

$$\text{Percentage} = \frac{205 - 45 \times 100}{1{,}220.7 - 45} = 13.6$$

It will be evident from this that, since the water has been raised 160 deg. by the use of the heater, a rise of 1 per cent of saving is found to be 160÷13.6=11.76 deg.

For approximating the percentage saved by a heater Kent states that each degree rise in the temperature of the water is equal to 0.0909 per cent, which is equivalent to dividing the total rise in temperature by 11.

Table I gives the exact values by which to multiply the degree rise in temperature to secure the percentage gain.

TUBE SURFACE IN CLOSED HEATERS

INITIAL TEMP.	FINAL TEMPERATURE			
	180	190	200	205
STRAIGHT TUBE WATER TUBE HEATER				
32	0.828	0.884	0.941	0.968
40	0.784	0.840	0.896	0.924
50	0.728	0.784	0.840	0.868
60	0.672	0.728	0.784	0.812
70	0.616	0.672	0.728	0.756
80	0.560	0.616	0.672	0.700
90	0.504	0.560	0.616	0.644
100	0.448	0.504	0.560	0.588
STEAM TUBE HEATER				
32	1.283	1.374	1.458	1.501
40	1.215	1.302	1.388	1.432
50	1.128	1.215	1.302	1.345
60	1.041	1.128	1.215	1.258
70	0.954	1.041	1.128	1.171
80	0.868	0.954	1.041	1.085
90	0.781	0.868	0.954	0.998
100	0.694	0.781	0.868	0.911
COIL HEATER				
32	0.745	0.795	0.847	0.871
40	0.705	0.756	0.806	0.832
50	0.655	0.705	0.756	0.781
60	0.605	0.655	0.705	0.731
70	0.554	0.605	0.655	0.680
80	0.504	0.554	0.605	0.630
90	0.453	0.504	0.554	0.579
100	0.403	0.453	0.504	0.529

TYPES OF FEED-WATER HEATERS.

By Charles L. Hubbard

FEED-WATER heaters are employed for 2 important reasons: First, if cold water is fed into a boiler in any considerable quantity the cooling effect will cause an unequal contraction of the plates, which is likely to produce leaks at the joints. It also tends to reduce the steam pressure, and necessitates more rapid firing for a time after feeding, unless the load upon the engine is practically constant, so that the feed valve can be set to supply a uniform quantity of water continuously.

Second, feed-water heaters can nearly always be arranged to utilize exhaust steam or waste gases from the furnace, so that a substantial saving in fuel is made by their use.

Classes.

Feed-water heaters are divided into 2 general classes, known as closed and open heaters; each class embodies 2 types, the vertical and horizontal, while a number of different constructions of each type are regularly built.

In the closed heaters the construction varies largely in the arrangement of the tubes. These are commonly known as single-flow, double flow, straight tube, bent-tube, water-tube, and steam-tube types, or may consist of a combination of certain of these features.

Heat Transmission.

The ability to heat feed-water in a closed heater depends upon the rate of heat transmission through the heating surfaces, and also upon the extent of these surfaces. Transmission of heat from steam to water through a unit area of tube surface in a heater varies between wide limits, depending to a considerable extent upon the velocity of the water passing over the heating surface, and to some extent upon the arrangement of that surface.

Accumulation of scale and oil tends to reduce the transmission of heat, while an increase in the velocity of the water increases it. In order to secure the best results the tubes should be made long and of small diameter, as this gives a moderately high velocity to the flow and also allows sufficient time to raise the water to the maximum temperature.

Water Velocity.

In a general way, a large number of small tubes is more efficient than a smaller number of large tubes. The velocities commonly employed in feed-water heaters, upon which the capacity is based, are as follows:

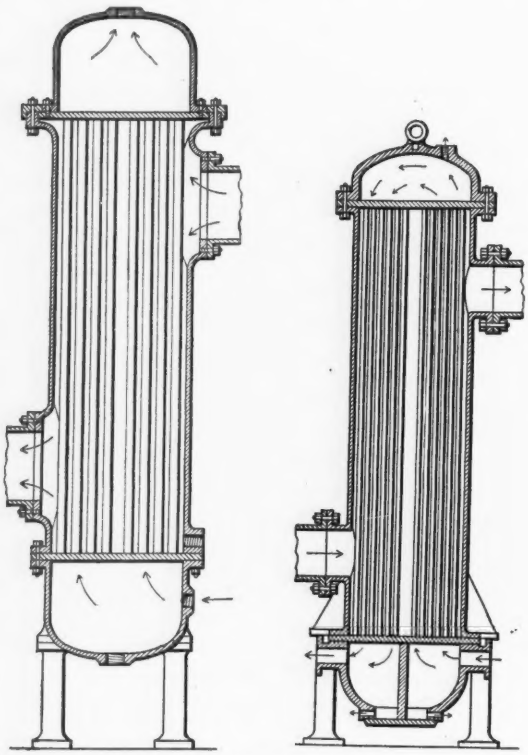
Single-flow, water-tube ..... 500 feet per hour
Double-flow, water-tube ..... 750 feet per hour
Coil .....8,400 feet per hour

As one boiler horsepower requires 34.5 lb. or 0.5528 cu. foot of water per hour, the combined net area of the tubes in square feet per horsepower is equal to 0.5528 divided by the velocity in feet per hour. In case of the coil heater, a single pipe is used when the required area does not exceed that of a 3 in. pipe. When a larger area is called for, 2 or more pipes of a smaller size are used.

The length of tubes or coils required depends upon the temperature of the steam and the mean or average temperature of the water passing through the heater.

Heating Surface.

Ordinarily, the heat units transmitted per square foot of heating surface per hour per degree difference



SECTION OF STRAIGHT TUBE SINGLE-FLOW HEATER

DOUBLE-FLOW HEATER

in temperature between the steam and water may be taken as follows:

Straight water-tube	178 B. t. u.
Bent water-tube	184 B. t. u.
Coil	200 B. t. u.

Assuming steam at atmospheric pressure, the temperature would be 212 deg. Assuming initial and final temperature of the feed water as 50 and 200 deg. respectively, the average temperature would be 125 deg. Knowing the above conditions the size and number of the tubes or coils can easily be determined in any particular case. In practice there is very little difference in the amount of heat transmitted through brass and iron tubes owing to the accumulations of oil and scale upon them. While the heat-conducting property of brass exceeds that of iron, the heat-absorbing power of iron is greater than that of brass.

Brass tubes are largely used in feed-water heaters because iron is more readily injured by the pure water which results from the condensation of steam.

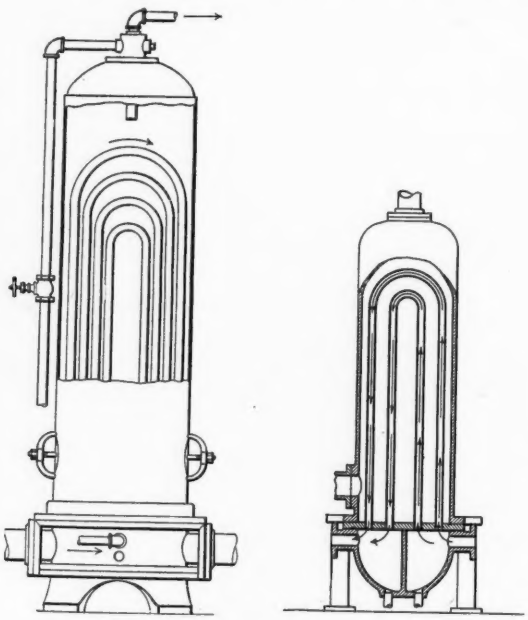
Typical Closed Heaters.

Figure 1 shows a section through a vertical straight-tube heater. This is of the single-flow type with cast-iron casing and drawn brass tubes. The water enters the bottom of the shell and passes upward through the tubes to be taken off at the top. Special means are provided for catching and blowing off the sediment as indicated. Exhaust steam enters the side of the shell near the bottom and flows outboard through an opening on the opposite side near the top.

Figure 2 shows a similar heater of the double-flow type, in which the water passes twice through the same tube length, as indicated by the arrows, provided the heater is the same height.

A return-bend steam-tube heater is shown in Figure 4. As both ends of the tubes are attached to the same tube-plate no other provision is required for expansion. The steam in this case is inside the tubes and the water surrounds them.

In Figure 5 is shown a similar construction ex-



RETURN BEND STEAM-TUBE HEATER

WATER-TUBE HEATER

cept that it is a water-tube instead of a steam-tube heater.

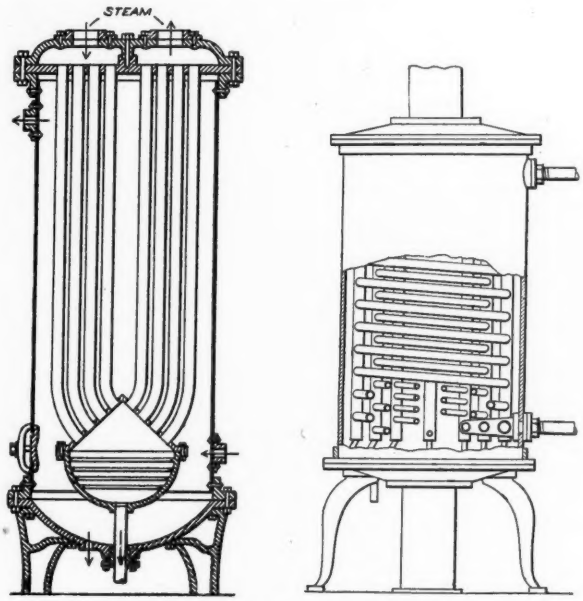
The action of the heater is indicated by the arrows. The feed water enters channel 1, flows upward through the tubes, which are shown in section, then downward and enters the settling chamber, from which the impurities may be blown off and whence it goes to the outlet.

Figure 6 shows a section through a heater of the bent-tube, double-flow, steam-tube type, the body or shell of which is of steel provided with heavy cast-iron flanges, to which are attached the top and bottom chambers, both made of cast-iron. The exhaust steam enters the top and passes down one section of the tubes into the enlarged space or chamber at the bottom, then upward through the other section of

tubes, thus passing twice through the entire length of the heater.

The chamber at the bottom where the flow of steam changes its direction acts as an oil separator and purifies the steam so that it can be used for heating purposes. The feed water enters near the bottom, passes upward around the tubes and is discharged near the top.

A surface blow-off is provided for blowing off the scum which rises above the outlet. The water passes



STEAM-TUBE DOUBLE-FLOW HEATER

WATER-TUBE COIL HEATER

slowly through the heater, allowing the sediment to settle to the bottom below the oil separator where it can be blown off.

At the lower ends, the tubes are bent to an angle of 45 deg. to make proper connection with the oil separator, which allows them to expand and contract freely, thus overcoming any tendency to work loose.

Figure 8 shows a section through a coil heater in which the heating surface consists of a copper coil with all joints made by lapping or brazing, no threaded or soldered joints being used within the shell.

In the heater shown there are 3 coils, 1 within the other and all 3 connected with the same inlet and outlet.

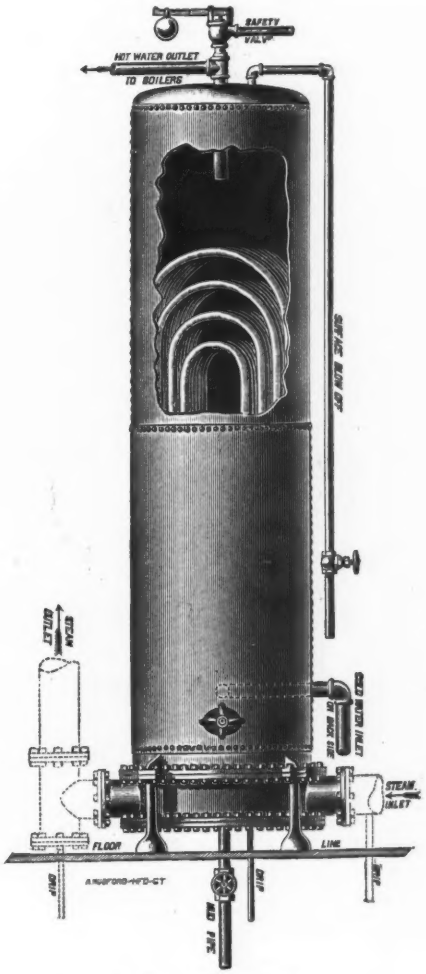
THE BERRYMAN FEED-WATER HEATER AND PURIFIER

I. B. Davis & Son, Hartford, Conn.

The body of the Berryman heater, as manufactured by this company, is of shell steel with flange steel heads, and is tested to 175 lb. pressure. It contains a large quantity of water, and ample time is thus afforded for all impurities to settle to the bottom.

The tubes are seamless drawn brass, made U shape, which permits both ends of each tube to be expanded into the same tube sheet, and thus they cannot be affected by expansion or contraction. The sheet into which the tubes are set is cast iron from 2 to 3 in. in thickness.

The water in the heater surrounds the tubes, and the impurities which are deposited in the bottom of the reservoir are drawn off through the mud blowoff which is at the lowest point of the concave tube sheet. The water enters the heater at the side, but at a sufficient distance from the bottom to prevent any disturbance in the sediment which has collected, and leaves the heater through the pipe which extends down a few inches from the top, and is thus taken out at the hottest point, while scum, which has risen to the top, remains undisturbed. The



I. B. DAVIS HEATER

scum blow is arranged for at the top of the heater, and provides for the removal of such scum and impurities as rise to the top.

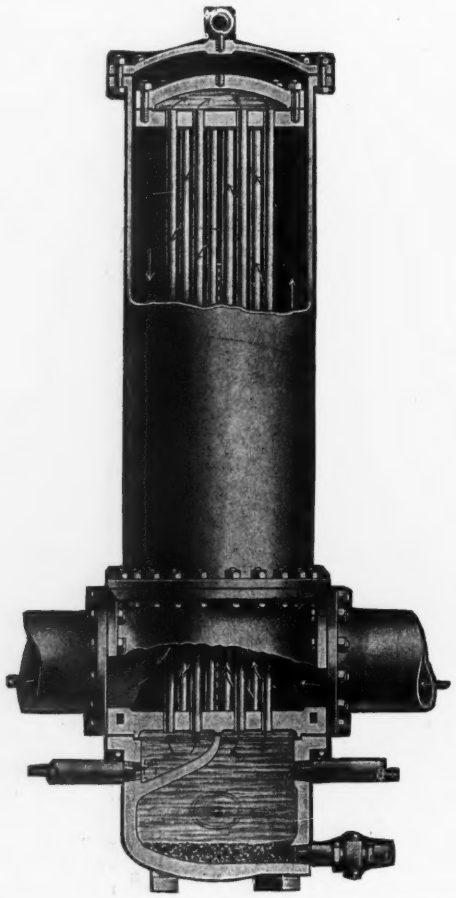
These heaters are designed in either vertical or horizontal types, and may be made for use in any location or system of piping.

ERIE CITY COUNTER-CURRENT FEED-WATER HEATER

Erie City Iron Works, Erie, Pa.

The illustration shows the counter-current feed-water heater, which is of the closed type, manufactured by this company. The exhaust steam entering on one side comes in contact with the baffle plate and passes up over and out at the other side. The water entering on the side opposite the exhaust entrance travels through the

brass tubes in a course directly contrary to the circulation of the steam, so that the hottest water comes in contact with the hottest steam.



ERIE CITY COUNTER-CURRENT FEED-WATER HEATER

The large settling chamber as compared with the small feed chamber gives more space for sediment and precipitates to settle, these being drawn off through the valve at the bottom. The tubes are made accessible for cleaning by removing the covers of the shell and of the circulating chamber. This heater can be cleaned both outside and inside without breaking any pipe joint.

GOUBERT WATER-TUBE FEED-WATER HEATER

Goubert Mfg. Co., New York

The Goubert feed-water heater is essentially composed of 2 cast-iron water chambers connected by a cluster of seamless drawn brass tubes which are rigidly secured at their ends to the tube plates by means of a roller tube expander. The whole upper chamber, which is carried solely by the tubes, is free to move up and down as these expand or contract under varying temperatures. The exhaust steam from the engine is admitted to the shell on one side and, spreading between the tubes, impinges upon them in its passage across to the outlet on the opposite side, while the aggregate area of the space between the tubes is so much greater than that of the exhaust pipe that no obstruction is offered to the flow of steam. Water of condensation is removed by the drip pipe, which should be kept always open.

OTIS HEATER, OIL SEPARATOR AND PURIFIER

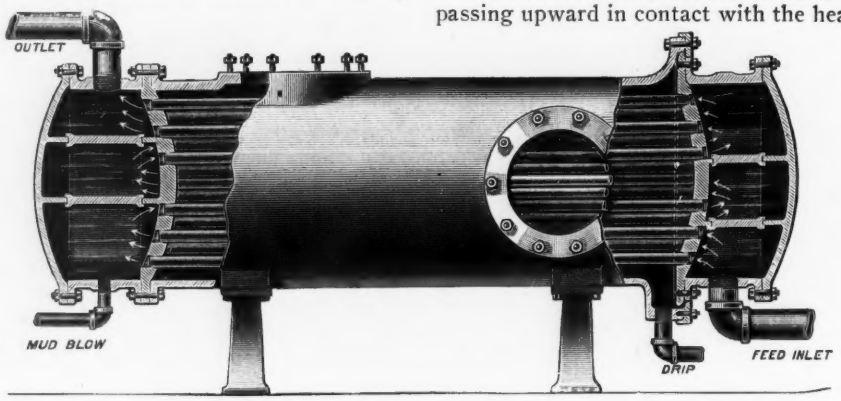
Stewart Heater Co., Buffalo, N. Y.

The enclosed feed-water heater here shown is designed to heat boiler feed water by exhaust steam, to separate sediment and foam from it and also to remove condensation and oil from exhaust steam.

The body of the Otis heater is made of boiler iron or steel, the top end of which is riveted to a heavy cast-iron ring with a projecting rim cast upon its outer surface, forming a flange to which the tube sheet and top dividing plate is attached by 1 row of bolts. The lower end of the shell is riveted to a heavy cast-iron ring, which is bolted to a cast-iron conical bottom supported by 4 legs, making a substantial base for the heater.

In the operation of the heater, exhaust steam enters and leaves the heater at the top, as shown in the cut, thus forming a cool settling chamber in the bottom. The exhaust steam upon entering the heater passes down 1 section of tubes into the enlarged space of the water and oil separator, where the water of condensation and oil is separated and the exhaust steam then passes up through the other section of tubes, thus passing twice through the entire length of the heater, heating the feed water to the boiling point. The exhaust steam can then be used for other purposes or exhausted into the atmosphere.

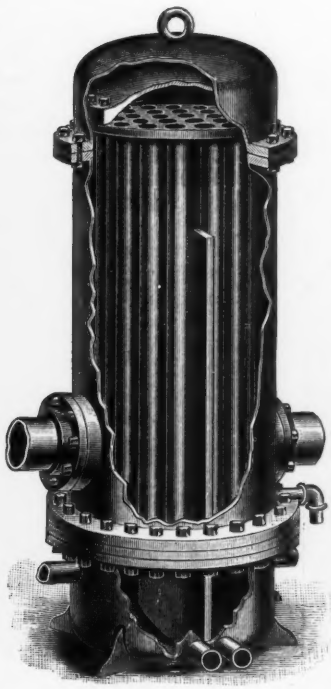
The water enters the heater near the bottom and passing upward in contact with the heated tubes, gradually becomes heated and is discharged as near the top as practicable without carrying the scum that is on the surface of the water into the boiler.



GOUBERT WATER-TUBE FEED-WATER HEATER

This feed water heater not only heats the feed water with the exhaust steam to the boiling point, but at the same time extracts the oil. You will notice the oil separator in this heater is held by the tubes in the center of the cool settling chamber near the bottom and as the cold feed water enters this heater at this point, about the center of the oil separator, the sides, top and bottom of the separator are surrounded at all times by this cold water. As the exhaust steam passes down the one section of brass tubes into the oil separator it must come in contact with these cold surfaces by passing through the two plates and over the projections that are cast on the inner surfaces of this oil separator and as oil chills very quickly when brought in contact with any cool surfaces, the oil will drop to the bottom of this separator and be carried off through the brass discharge pipe that leads from the bottom of this oil separtor through the stuffing-box in the conical bottom of the heater. The water of condensation can then be returned to the boiler free from oil.

THE OTIS HEATER, OIL SEPARATOR AND PURIFIER

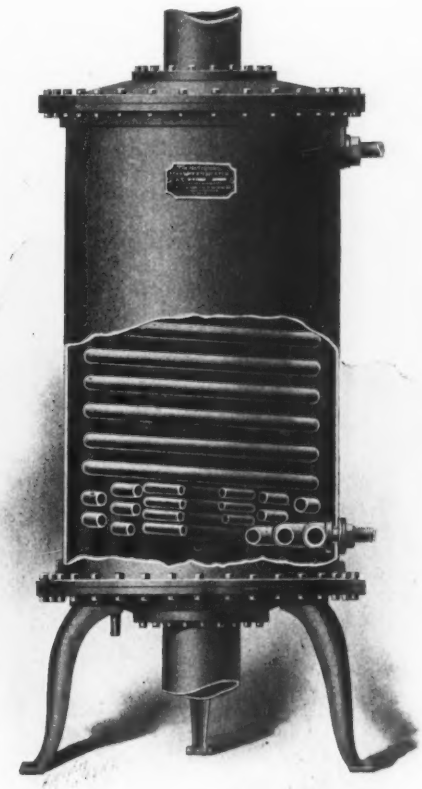


JACOBS WATER TUBE FEED-WATER HEATER AND PURIFIER

JACOBS WATER TUBE FEED-WATER HEATER AND PURIFIER

Chas. Jacobs & Co., Boston, Mass.

The Jacobs Heater is a cast-iron shell containing seamless drawn brass tubes expanded into place at the top and bottom. A water chamber is in the base, having a partition through the middle which causes the feed water upon entering the heater to pass upward through the tubes on one side of the partition, then downward through the tubes on the other side to the outlet. The tubes being surrounded by a cap having a chamber at the top and being fastened rigidly only to the lower tube plate, free play is given for expansion.



NATIONAL FEED-WATER HEATER

The exhaust chamber or shell of the heater has a partition extending upward a portion of its height, which causes exhaust steam upon entering to pass upward and around the tubes on one side of the partition, then downward and around the tubes on the other side to the outlet.

The drip opening at the bottom of the exhaust chamber provides for draining off condensation, while a blow-off of both sections of the base allows for complete removal of all sediment. Should it become necessary to clean the tubes, remove the top cap of shell and the cover of the upper water chamber.

NATIONAL FEED WATER HEATER

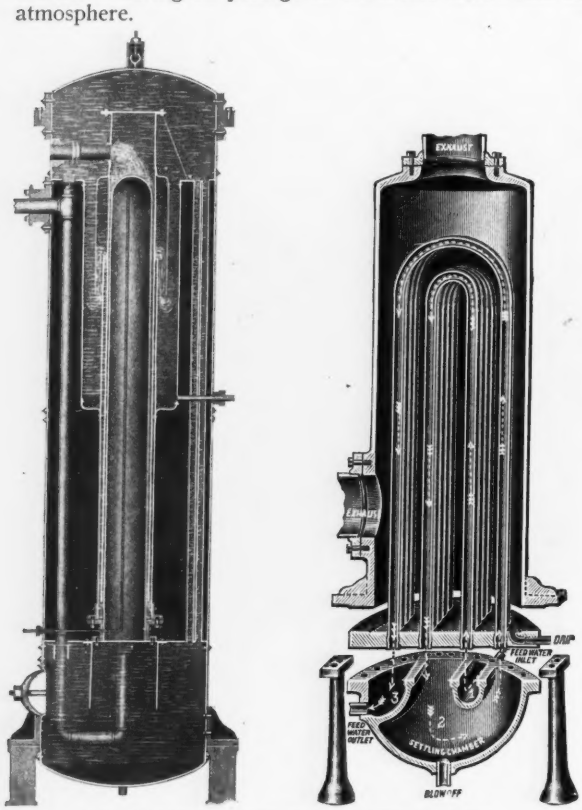
National Pipe Bending Co., New Haven, Conn.

An enclosed coil type of heater is manufactured by this company for heating boiler feed water by means of exhaust steam. These heaters range in capacity from 5 to 4,000 h. p. and consist of from 1 to 14 coils of seamless drawn brass or copper tubing incased in a cast-iron or steel shell to which exhaust steam is admitted, heating the water which passes through the coils. A drip pipe is attached to the bottom of the steam chamber which draws off oil and condensed steam.

THE LOEW CLOSED FEED-WATER HEATER

The Loew Mfg. Co., Cleveland, O.

Materials used in the construction of the Loew closed heater are principally cast iron and brass, the shell, legs and caps being of cast iron and the tubes of straight seamless drawn brass. Both ends of these tubes are rolled into tube plates and the lower tube plate is bolted to the casting at the bottom of the apparatus, making it stationary. The upper tube plate, however, is free from the outer shell, allowing the tubes to expand and contract at will under the influence of varying temperatures and strains. The exhaust steam enters the heater at the steam inlet, completely filling the shell and enveloping the tubes during its passage to the steam outlet into the atmosphere.



LOEW CLOSED TYPE FEED-WATER HEATER

PATTERSON-BERRYMAN FEED-WATER HEATER AND PURIFIER

The cold water is admitted through the water inlet and is divided into 2 columns flowing upward through the first series of tubes to the port at the upper end of the partition, where the current of the water is directed by the partition to the next group of tubes, continuing this course until the water is passed 6 times through the exhaust steam, bringing it to the water outlet on the opposite side of the apparatus, through which it passes on its way to the boiler. The interior parts of the heater are easily accessible for cleaning; it is provided at the bottom with mud blow-offs, to which access may be had at any time, and the bonnets or caps at the top may be removed and the bottom section of the heater dropped to the floor. This leaves both ends of the tubes exposed.

PATTERSON-BERRYMAN FEED-WATER HEATER AND PURIFIER.

Frank L. Patterson & Co., New York

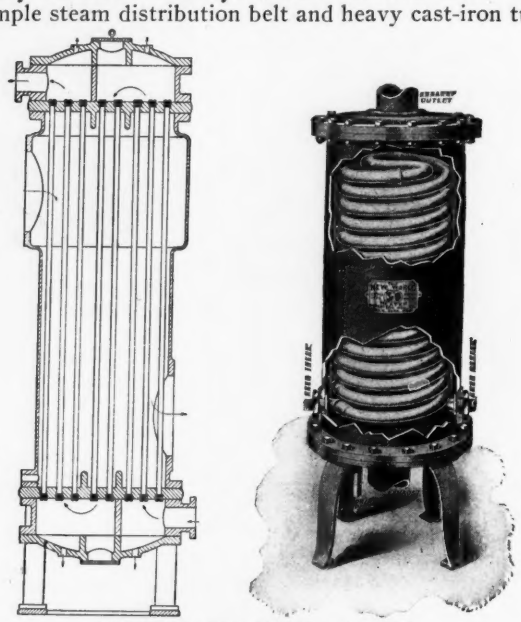
The closed feed-water heater here illustrated is made of cast iron or brass, and of sufficient weight to insure strength. Its construction will be clearly understood from the sectional cut. Water first enters the channel, 1, the only outlet from which is upward through the inside row of tubes, one of which is shown in section. After passing around through the inside row of tubes the feed water reaches the settling chamber, 2, where the impurities may be blown off and from which it goes to the outside row of tubes. After flowing around through these the feed water finally enters the last compartment, 3, into which is tapped the outlet to the boiler.

Exhaust steam enters the shell through the side and is exhausted through the top or may take the reverse course. The larger sizes of these heaters contain 3 or 4 rows or tubes, their principle of circulation being the same. The feed water is split into columns and passes through the exhaust steam contained in the shell as often as there are rows of tubes in the heater, obtaining the benefit of all the heat in it. One of the advantageous features of this heater is the ready accessibility of its interior without disconnecting the exhaust pipe or disturbing the shell on its legs. This can be accomplished by removing a few bolts and lowering the settling chamber.

WHEELER FEED-WATER HEATER

C. H. Wheeler Mfg. Co., Philadelphia, Pa.

The feed-water heater manufactured by this company consists of a cylindrical cast-iron shell with ample steam distribution belt and heavy cast-iron tube



WHEELER FEED-WATER HEATER

THE ROBERTSON RETURN COPPER COIL FEED-WATER HEATER

heads at each end. The tubes are of seamless dra n brass with straight, plain ends and 1.25 in. outside diam. These are secured into the tube heads by heavy shouldered brass ferrules and asbestos packing, freely providing for expansion and contraction of the tubes while at the same time securely holding them in position.

The water ends are of cast-iron arranged to give the water 3 travels through the interior of the tubes, in this way thoroughly breaking it up and obtaining the maximum heat transference. The end covers are arranged for removal without breakind any pipe joints and the entire construction is such that it will permit of the easy removal or replacement of any tube or

tubes, and to clean readily the interior of the tubes if necessary; although in practice it is found that this is very seldom required.

These machines are built in the horizontal and vertical types and for primary and auxiliary practice in all sizes from 30 to 6000 hp. In the former case the heater is located in the main exhaust line; and the latter, which is used when the units operate condensing, the heater receives its exhaust from the auxiliaries.

THE ROBERTSON RETURN COPPER COIL FEED-WATER HEATER

Jas. L. Robertson & Sons, New York

In this closed feed-water heater, it will be noticed that the feed inlet and outlet at the bottom of the heater give the body of the coil perfect freedom for expansion and make it convenient for connecting. The heating surfaces are constructed with seamless drawn copper tubing connected to patent manifold gun metal fittings. All joints inside the shell are made by expanding, lapping and brazing, and the coils are tested to 600 lb. hydraulic pressure, before leaving the factory.

Other points of construction and the operation of the heater are clearly shown in the illustration.

THE VOLZ COMBINATION SURFACE CONDENSER AND FEED-WATER HEATER

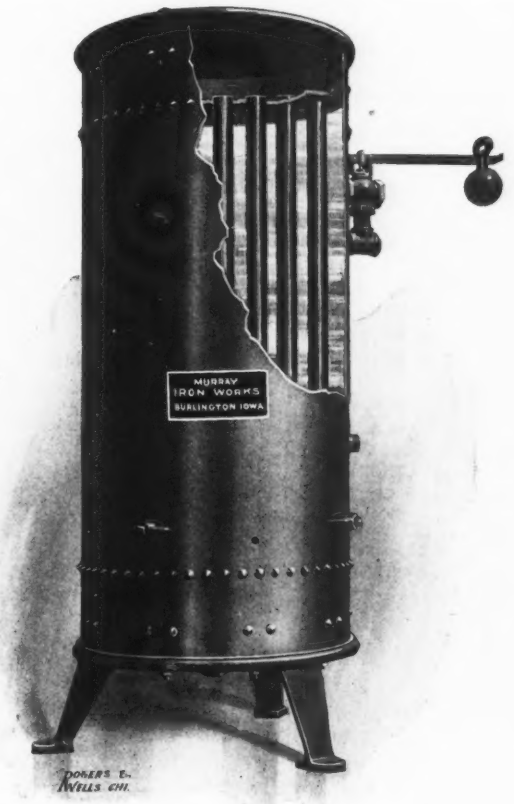
Wheeler Condenser & Engineering Co., Carteret, N. J.

The Volz combined surface condenser and feed-water heater meets the requirements of both these appliances in a manner that is simple as well as practicable. The feed-water heater is incorporated in the upper part of the condenser shell, certain tubes being set aside for heating the feed water and communicating at either end with suitable inlet and outlet passages separate from the regular circulating water passages. These tubes are placed near where the exhaust steam enters and therefore receive the benefit of the full temperature of the exhaust. They are of the same size as the condenser tubes and heat the water quickly, as it is broken up into many small streams. As will be noted from the illustration, these tubes require very little additional space. The location of the heater tubes above the condenser tubes protects the latter from sudden and violent changes in temperature.

THE MURRAY CLOSED FEED-WATER HEATER

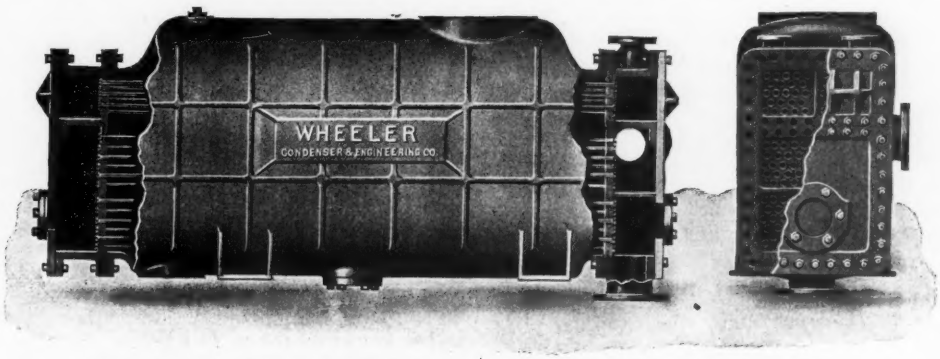
Murray Iron Works Co., Burlington, Iowa

The closed or pressure feed-water heater manufactured by this company is of the tubular type, with steam chambers at each end of the shell. The inner heads are connected by 2-in. tubes, and the outer cast-iron heads are held in place by stud bolts, permitting them to be readily removed. Exhaust steam entering this heater at the bottom, passes through the tubes, which are surrounded by the feed water, to the upper chamber, and is exhausted through the outlet at the top. The feed water



THE MURRAY CLOSED FEED-WATER HEATER

is forced through the heater into the boiler by the feed pump or injector and is heated, in passing, by contact with the tubes through which the exhaust steam passes. The relief valve shown is on the feed-water pipe to the boiler to prevent the pump putting undue pressure on the heater should the globe valve between it and the boiler be shut or the check valve fail to work. Hand holes are conveniently placed for ready access to the interior of the heater for cleaning.



THE VOLZ COMBINATION SURFACE CONDENSER AND FEED-WATER HEATER

ing to the size of the heater, through the heating chamber.

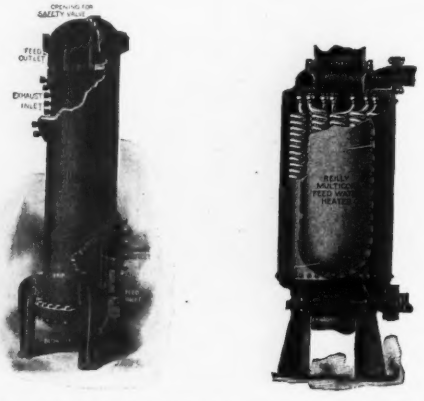
THE WAINWRIGHT HEATER.

Alberger Condenser Company, New York, N. Y.

One of the most important problems in heating water is to agitate it thoroughly, so as to bring all particles of the water into contact with the heating surface, which the Wainwright heater does by breaking up the water into small columns, which are in turn broken up by the corrugations in the tubes.

This heater is of the closed type, either vertical or horizontal, and all parts, with the exception of the heating surface, are made of cast iron, as this has been found to be the most suitable metal to withstand the action of the fatty acids contained in the exhaust steam which is ordinarily used as the heating medium. The heating surface consists of seamless drawn pure copper tubes, obviating the trouble so frequently experienced with the splitting of brass tubes.

The steam tube type can be furnished but the water tube type is strongly recommended, and there is prac-



THE WAINWRIGHT CORRUGATED TUBE HEATER
REILLY MULTICOIL HEATER

tically no installation where it could not be adopted to advantage in place of the steam tube type. The corrugated copper tubes used act as expansion joints, and accommodate the difference in expansion between the cast-iron shell and the copper tubes. Owing to the use of this type of heating surface the tubes may be rigidly fastened into the tube heads, thus obviating all possibility of leakage.

The Wainwright heater is provided with large settling chambers in which the solids and other foreign substances are accumulated, these chambers being provided with ample blowoff connections which admit of their being cleaned at frequent intervals.

A very important feature of the corrugated tube is that the revolving motion given to the water produces a scouring effect on the tube, resulting in its remaining clean much longer than the smooth tube does.

REILLY MULTICOIL HEATER

The Griscom-Spencer Co., New York

The construction of the Reilly multicoil heater is unique in several particulars. In the first place, the heating surface consists of a series of small coils, rolled from seamless drawn copper tubing. These coils are connected to the distributing headers by means of screwed ground union joint connections, and every coil is the same size and is removable and interchangeable. The water to be heated flows at high velocity, about twice that of the water in the feed pipe, through the coils, and the steam surrounds the coils. The passage of steam through the heater shell is almost unobstructed. There is a large door in the shell of the heater which permits of free access to the internal connections without having to break any of the feed or exhaust steam connections to the heater. The union connection used to hold the coils to the headers is as illustrated in the cut. Each coil is tested to a pressure of 600 lb. per sq. in. before it is connected in the heater. The coils are then inserted through the door, and the union connections made tight.

The construction of the union joints is such that it may be made tight against any working pressure desired. The absolute elasticity of the cooper coils positively prevents any strain being transmitted to the joints.

The use of the small diameter copper coils, corrugated especially as they are, secures for this construction a high efficiency, so that a high temperature of the feed water may be had. The flow of water through the tubes acts constantly to scour the inside of the tubes clean and smooth, because at every instant of its travel the direction of the water is being changed and changed sharply, the result is that flowing at a high velocity the friction of the water against the tube surfaces is such as to scour so thoroughly that scaling up of the tubes does not occur. Such scale as does form will be carried to the settling chamber at the bottom of the heater, or to the special filter provided for this purpose.

AMERICAN STANDARD COPPER COIL FEED-WATER HEATER

The Whitlock Coil Pipe Co., Hartford, Conn.

The parts of this closed feed-water heater are a cast-iron or steel shell and a series of copper water coils. The distinct feature of this heater is that copper is used for the heating coils, the advantages of copper over brass for this purpose being that it is a better conductor of heat, the danger of cracked tubes is not so great and the metal is more easily worked in case of repairs.

Exhaust steam enters at the bottom of the heater, circulates between the heater coils and exhausts through the top head to the atmosphere. The feed water is brought in at the top, preferably, passes through the coils and to the boiler from the outlet pipe. The construction is shown in the right hand cut, first column, of p. 47.

THE SIMS CLOSED FEED WATER HEATER

The Sims Co., Erie, Pa.

With the exception of the larger sizes, these heaters are made entirely of cast-iron; the larger sizes having steel in part of their construction are well protected from corrosion because the base is cast-iron in one piece.

Seamless brass tubes, 1.5 in. outer diameter, are used in all sizes, straight rolled into a fixed head at one end and loose head at the other, thus taking care of expansion and contraction without strain. These tubes are arranged in groups for the purpose of properly circulating water through them. The covers of the tube plates have suitable walls or partitions cast in them, forming a series of headers or pockets, conducting the water from tube to tube or series of tubes, thus requiring it to travel from 12 to 6 times,

OPEN TYPE FEED-WATER HEATERS

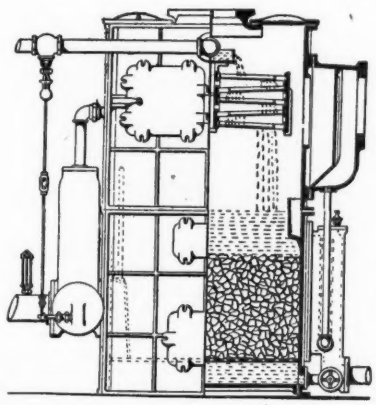
By Charles L. Hubbard

TWO general forms of construction are in common use in the open heater, known as the "pan," and the "plate" or "tray."

In the first arrangement shallow pans, either round or rectangular, are placed one above another, each alternate pan discharging at the outer edge and the others nearer the central column or centers of the pans. The pans which discharge from the outer edge are made somewhat smaller than the others so that the water will fall directly into the one below.

When plates or trays are used they are placed one above another and alternate ones inclined slightly in opposite directions so that the water flows backward and forward across the heater as it descends to the bottom. In both types, the water is broken up into a film or spray so that it mixes intimately with the steam and thus absorbs its heat.

Open heaters and purifiers possess an important advantage in being able to heat water to the maximum temperature regardless of the condition of the interior surfaces with respect to cleanliness. This, however, applies only to their use as heaters, as accumulations of mud and scale beyond a certain point may render them inefficient as purifiers.



CAST-IRON RECTANGULAR OPEN HEATER

Exhaust heaters should be proportioned according to the quality of the water to be used, the size being increased with the amount of mud or scale-producing properties which the water contains regardless of the quantity of water to be heated. For example, where muddy water is used a heater 2 or even 3 times as large may be required to produce the same results as would be necessary for clear water. This is because a larger settling chamber is required in order to allow sufficient time for precipitation. When scale-making elements, such as carbonates of lime and magnesia only must be taken care of, the heater need not be as large.

Proportions

The general proportions of an open heater will depend somewhat upon the arrangement of the trays or pans, but an approximation of the size of shell for a cylindrical heater may be obtained as follows:

Divide the total weight of water to be heated per hour by the weight of steam used per horsepower hour by the engine, and divided this quotient by a constant, which for clear water is 8, for slightly muddy water is 6, and for very muddy water is 2.15. The resulting quotient if divided by the sectional area of the heater in square feet gives the length of the shell in feet and vice-versa.*

Pan Surface

The pan or tray surface varies according to the quality of the water, both as regards the amount of mud and the scale-making ingredients. The surface in square feet for each 1000 lb. of water heated per hour may be taken as follows:

	Vertical Type.	Horizontal Type.
Very bad water.....	8.5	9.1
Medium muddy water.....	6	6.5
Clear and little scale.....	2	2.2

Small pans, 2.5 sq. ft. or less in area, are usually made circular in form, while larger sizes are generally made rectangular. The space between the pans is made not less than 0.1 the width for rectangular and 0.25 the diameter for round pans. Under ordinary circumstances it is not customary to use more than 6 pans in 1 tier, in order to obtain a low velocity over each pan.

SQ. FT. PAN SURFACE FOR OPEN HEATERS

POUNDS OF WATER HEATED PER HOUR	VERTICAL			HORIZONAL		
	VERY BAD WATER	MEDIUM QUALITY	CLEAR, AND LITTLE SCALE	VERY BAD WATER	MEDIUM QUALITY	CLEAR, AND LITTLE SCALE
500	4.25	3	1	4.55	3.23	1.1
1,000	8.50	6	2	9.10	6.46	2.2
2,000	17.00	12	4	18.20	12.92	4.4
3,000	25.50	18	6	27.30	19.38	6.6
4,000	34.00	24	8	36.40	25.84	8.8
5,000	42.50	30	10	45.50	32.30	11.0
6,000	51.00	36	12	54.60	38.76	13.2
7,000	59.50	42	14	63.70	45.22	15.4
8,000	68.00	48	16	72.80	51.68	17.6
9,000	76.50	54	18	81.90	58.14	19.8
10,000	85.00	60	20	91.00	64.60	20.2
12,000	102.00	72	24	109.20	77.52	26.4
15,000	127.50	90	30	136.50	96.90	33.0
20,000	170.00	120	40	182.00	129.20	44.0
25,000	212.50	150	50	227.50	161.50	55.0

Settling Chamber

The size of the storage or settling chamber in the horizontal type varies from 0.25 to 0.4 of the volume of the shell, depending on the quality of the water; 0.33 is about the average. In the case of vertical heat-

---

* $A = \frac{H}{a \times L}$

$L = \frac{H}{a \times A}$ in which

A = Sectional area of shell in sq. ft.

L = Length of shell in linear ft.

H = Total weight of water to be heated per hour divided by the weight of steam used per horsepower per hour by the engine.

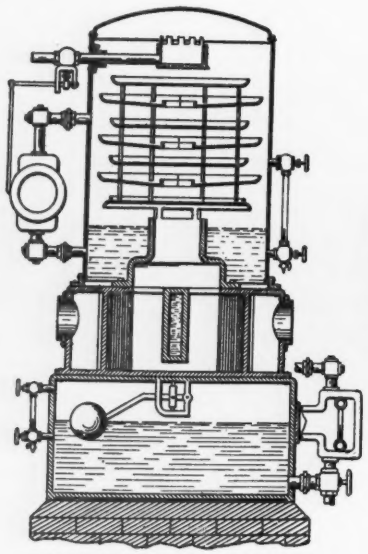
a = 2.15 for very muddy water.
= 6.0 for slightly muddy water.
= 8.0 for clear water.

ers, this varies from 0.4 to 0.6 of the volume of the shell. Filters occupy from 10 to 15 per cent of the volume of the shell in the horizontal type and from 15 to 20 per cent in the vertical.

Details of Heaters

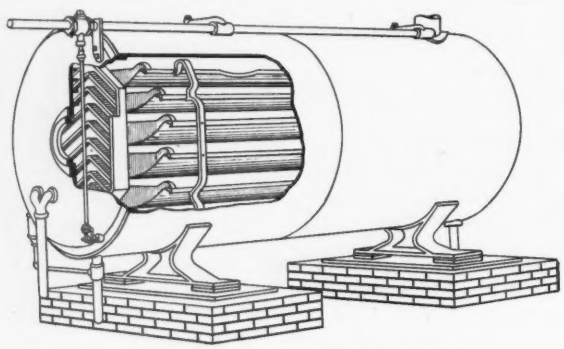
Figure 1 shows a sectional view of a rectangular heater and purifier, the shell being of cast-iron plates bolted together. Before entering the heating chamber the exhaust steam passes through an oil separator, which is bolted to the outside of the shell.

The upper portion of the heater contains removable trays, which are inclined, with the edge over which the water flows saw-toothed for breaking up the water. Each set of trays is suspended in the steam space with passages for the free admission of steam between them. The cold feed-water enters at the top and flows downward over the trays as shown.



ROUND TYPE OF OPEN HEATER

The round type of open heater and purifier is shown in Fig. 2 and is composed of the heating, the oil separating and the filtering chambers. Steam enters the center chamber, where the oil is caught by baffle plates placed before the exhaust inlet and outlet.



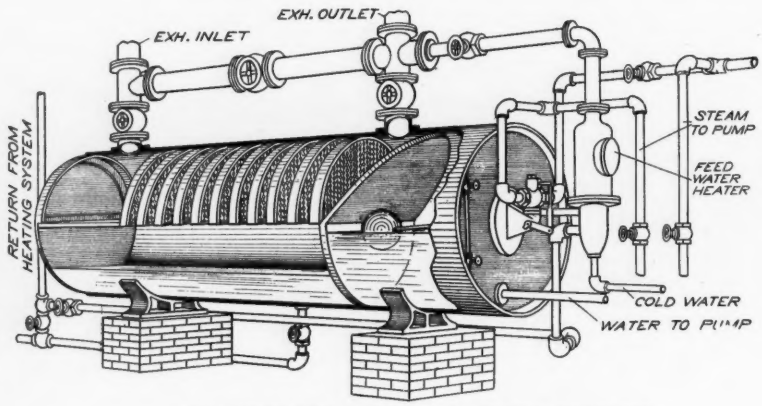
HORIZONTAL TRAY TYPE HEATER

In noncondensing plants, the steam enters at one side and discharges from the other. Only sufficient steam passes up through the central tube to heat the feed water.

In condensing plants or where there is a limited amount of exhaust for heating the feed water the whole passes up through the central tube, and any remaining portion not condensed is discharged at the top of the heater.

The cold feed water is admitted at the top and falls over a series of pans, as shown, to the filter chamber, located at the bottom.

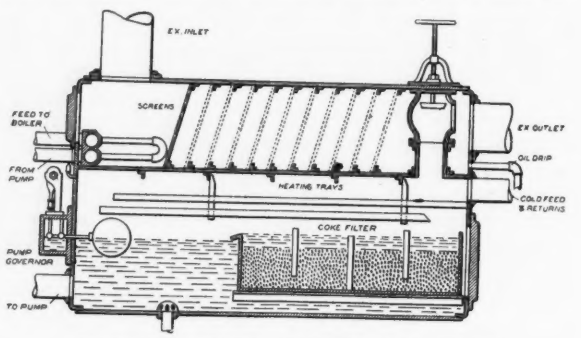
The horizontal type of the open heater as shown in Fig. 3 is especially designed to be used where the water is bad, and 1 peculiar advantage comes from the fact that the water flows along the underside of the pans so that the lime formation comes in direct contact with the exhaust steam no matter how thick the formation may be. An oil separator is provided at the steam inlet and a float operates a balanced valve for the regulation of the feed water.



OIL EXTRACTOR, HEATER AND PUMP GOVERNOR

Another form of horizontal heater and purifier is shown in Fig. 5, the operation being clearly indicated by the notes in the cut.

A combined oil separator, heater, and pump governor is shown in Fig. 4. This machine is especially adapted to office-building plants and similar installations, since ample provision is made for taking care of the returns from the heating system, purifying the water and automatically returning it to the boilers. The oil separator in this case is made up of a series of chains hung in iron frames and shown in the upper part of the shell. The feed water is heated in a separate chamber, shown at the right, into which it is thrown in the form of a spray and mingles directly with the steam, which is supplied at the top of the chamber through a special connection with the exhaust main.

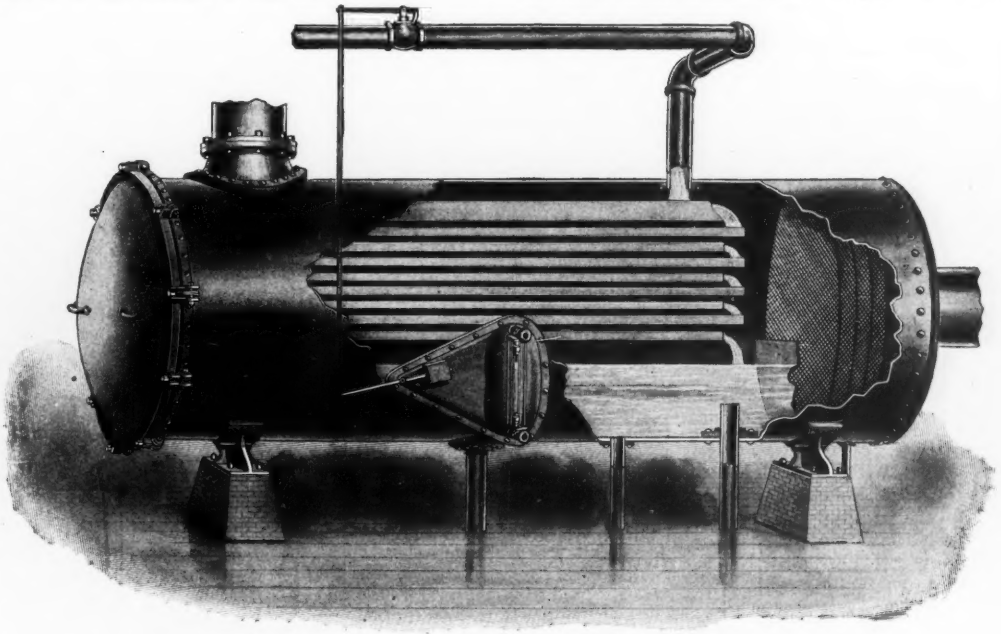


COMBINED HEATER, PURIFIER AND FILTER

BARAGWANATH HORIZONTAL OPEN HEATER

Wm. Baragwanath & Son, Chicago, Ill.

This heater is provided with removable pans, set in angle iron racks over which the water flows backward and forward the full length of the heater, several times before it is discharged to the reservoir and settling chamber at the bottom of the heater.



BARAGWANATH OPEN HEATER AND PURIFIER

The head is removable; made as light as consistent with strength and attached to the shell of the heater with swing bolts which make it easy to handle. The gasket making the joint is semi-hard rubber stretched on the ring, riveted to the shell, and can be used many times without renewal.

On entering the heater, exhaust steam passes through a series of perforated heads which serve as an efficient oil separator. After passing through the oil separator, the steam enters the heating chamber where it comes in direct contact with the feed water in the pans, and is then exhausted through the outlet at the top.

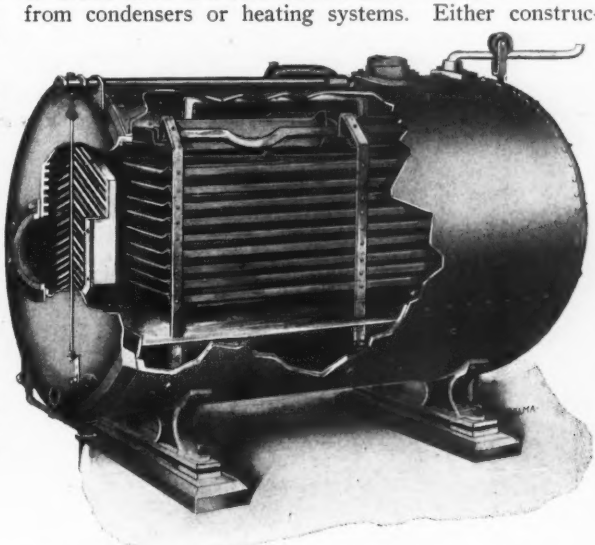
Feed water enters the heater through an automatically controlled valve which is operated by means of a float and lever in the reservoir, and thus maintains a constant level of the water in the heater. After passing over the pans, where the scale forming material is deposited in large quanties, water falls to the reservoir and is drawn through the suction pipe to the pump. This reservoir is provided with a blowoff to remove sediment, and an overflow for the removal of floating impurities.

HOPPES EXHAUST STEAM FEED-WATER HEATER AND PURIFIER

The Hoppes Mfg. Co., Springfield, O.

Hoppes exhaust steam feed-water heaters and purifiers are built on the same general plan and operate on practically the same principle as the live steam feed-water purifier made by this company, only the heating agent is exhaust instead of live steam, and they do not run under boiler pressure.

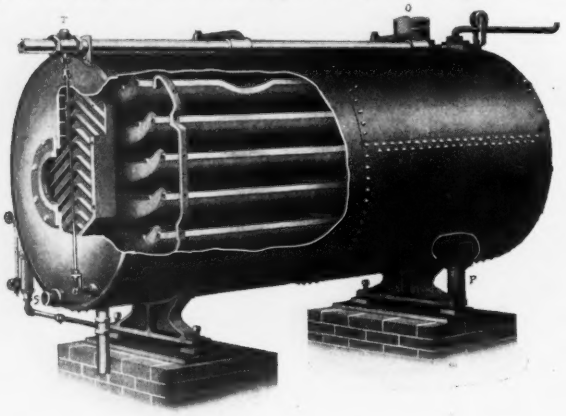
They are built in 2 constructions, the standard steel and the cast iron. The standard steel heater is especially adapted to the handling of water containing large quantities of scale-making solids on account of its exceptionally large heating and lime-catching surface, while the cast-iron construction heater is generally recommended for use where the water is only moderately impregnated with scale-forming substances, is of a corrosive nature, or where there is a considerable amount of return water from condensers or heating systems. Either construction, however, will give good results under any normal condition, as both contain ample heating and lime-catching surface to afford the highest possible temperature obtain-



HOPPES EXHAUST STEAM FEED-WATER HEATER AND PURIFIER

able from exhaust steam and consequently the greatest purifying efficiency, the principal distinction being that the cast iron is less liable to corrosion and pitting where the water is of corrosive nature.

The feed-water supply to heater is controlled by a balanced, automatic regulating valve of special design, governed by a ventilated copper float, and every machine



HOPPES CAST-IRON HEATER

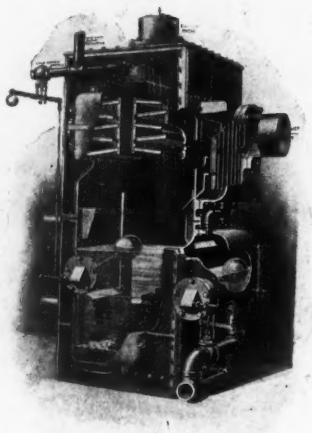
is equipped with a large and efficient oil extractor, crane for handling the removable head, water column with gauges and glass and all fittings necessary to make it complete and ready for piping.

The Standard construction is built in single units up to and including 3,500 hp. and the cast iron construction in sizes up to and including 30,000 hp.

COCHRANE FEED-WATER HEATER

Harrison Safety Boiler Works, Philadelphia, Pa.

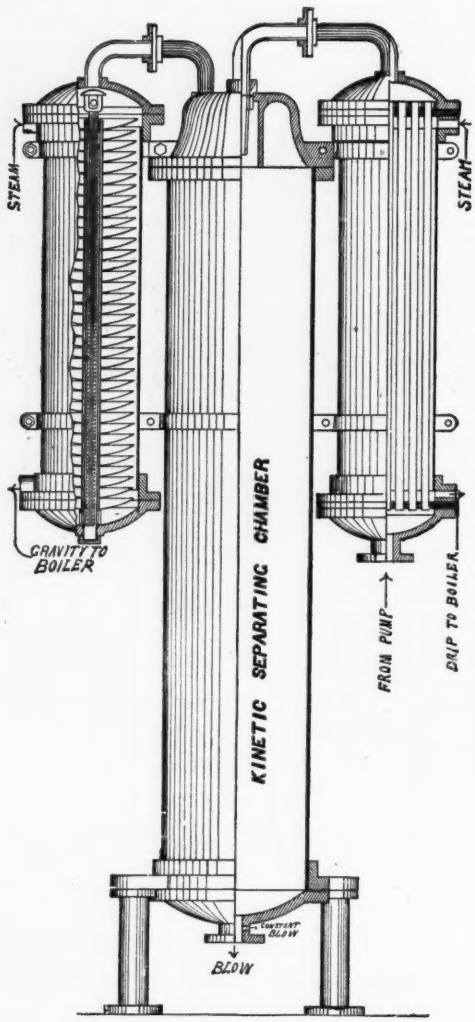
The Cochrane feed-water heater is of the open type, and is equipped with a Cochrane oil separator of similar construction to that described in another article, by means of which the oil is removed from the exhaust before entering the heater. The upper part of the heater is equipped with ample tray surface for the retention of the



COCHRANE FEED-WATER HEATER

lighter impurities and for thoroughly breaking up the water supply to make the intimate contact with the steam possible. The water is heated to the boiling point before falling into the reservoir beneath. This reservoir may be equipped with a filter of coke or other approved material.

A float mechanism is provided for the automatic regulation of the water supply to the heater, and a similar mechanism for the drainage of the external trap and overflow, so that the minimum of care and attention is necessary. The material entering into the construction of the Cochrane heater is, as far as possible, cast iron, which resists the deteriorating action of the water caused by acids and other impurities which it contains. The



THE BERRY FEED WATER PURIFIER

design permits of easy access to the interior for examination or for cleaning purposes.

The H. S. B. W. hot process system of water purification takes advantage of the fact that water can be softened more cheaply and more expeditiously hot than cold. As the water is heated the necessary chemical reagent is added by means of pump feed, which proportions the chemical according to the amount of impurities contained in the water. The tray surface in the upper part of the heating chamber retains a part of the lighter impurities, and the remainder are precipitated in a settling chamber provided in the bottom of the apparatus, which is also equipped with a filter through which the

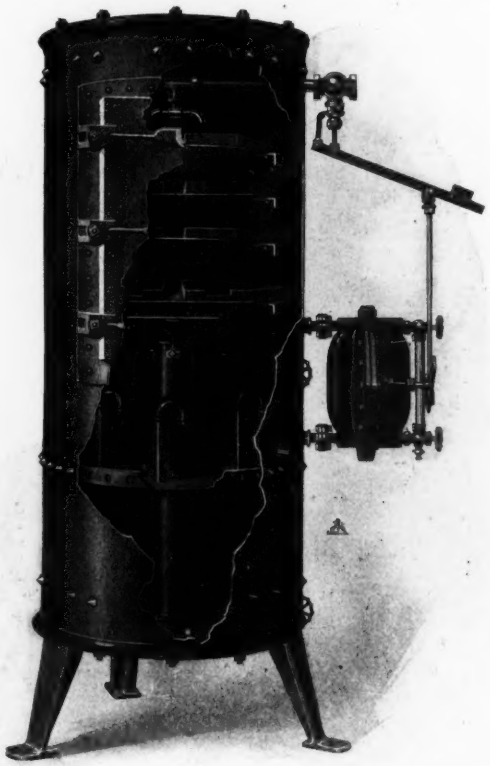
water must pass vertically upward before passing to the boiler feed pump.

This settling and storage chamber is also equipped with a patented supplementary by-pass, noteworthy because of the absence of valves and yet automatic and reliable in its operation, insuring the boiler feed pumps a full supply of hot treated water at all times, even though the system is not given the care and attention to which it is entitled.

BERRY FEED-WATER PURIFIER

Berry Engineering Co., Chester, Pa.

The live steam feed-water purifier manufactured by this company consists of an enclosed heater compartment, a separating chamber and a reheating chamber.



MURRAY OPEN FEED-WATER HEATER AND PURIFIER

The feed water from the pump enters at the lower part of the enclosed heater compartment, is forced up through the tubes which are surrounded by live steam, and is conducted to the settling chamber. Here the heavy impurities are precipitated and may be removed through the blowoff at the bottom. This precipitation is accelerated by the kinetic energy imparted as the water is rapidly injected downward through a contracted nozzle. From the top of this chamber the water is forced into the reheating chamber where it is conducted over a series of surfaces which are surrounded by live steam, and to which the lighter particles, oils and the like, adhere. From this compartment the water flows by gravity to the boiler.

Live steam connections are made to the boiler from the points marked steam in the illustration, and the drip from the closed heater compartment is led back to the boiler from the opening shown at the bottom.

The features of this machine are, first, the use of energy to accelerate the separation of heavy impurities; second, surface adhesion to remove oils, etc.; third, facilities for cleaning and removing accumulated impurities.

MURRAY OPEN FEED-WATER HEATER AND PURIFIER

Murray Iron Works Co., Burlington, Iowa

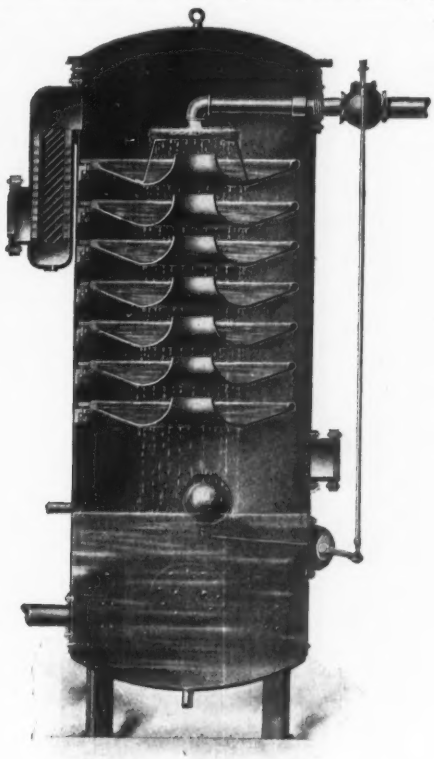
In the open feed-water heater, shown in the illustration, the water supply is regulated by an automatic float valve which admits only as much water as the boiler requires. The water first passes over a series of removable pans which take out such impurities as will precipitate at the temperature maintained, then it passes to the settling chamber where the oil and other floating impurities are skimmed off. From this compartment the water is drawn to the bottom suction chamber through a series of syphon pipes which take pure water from beneath the surface in the settling chamber. Here it is kept hot by the exhaust steam pipe which passes through it.

Exhaust steam entering through the pipe at the bottom of the heater is deflected by the plate over the top of this tube, and fills the space around the scale pans, thus heating the feed water to a high degree.

WICKES OPEN EXHAUST STEAM FEED-WATER HEATER AND PURIFIER

Wickes Boiler Co., Saginaw, Mich.

The Wickes open feed-water heater, as illustrated, consists of basins for heating and collecting precipitates from the water, a water chamber for receiving the heated water, a filtering chamber when desired, a float and valve for controlling the incoming fresh



WICKES OPEN EXHAUST STEAM FEED-WATER HEATER AND PURIFIER

water, a full complement of flanges, nozzles and taps for exhaust outlet, suction to pump, overflow and blowoff. The manhole plate removed from the heater permits a man to enter the water chamber when the whole heater, including the basins, can be fully examined and cleaned. For a full cleaning, requiring the removing of the basins, the top head of the heater is removed and the basins lifted out.

Water entering through the automatically operated inlet valve and pipe is conducted to the header, which overflows to the upper basin. This basin in turn overflows to the second, and this operation is continued until the water drops from the lower basin to the water chamber at the bottom of the heater. From here it is drawn through the outlet pipe to the boiler. Scum is taken from the surface of the water through the overflow pipe and sediment removed from the bottom of the heater through the blowoff.

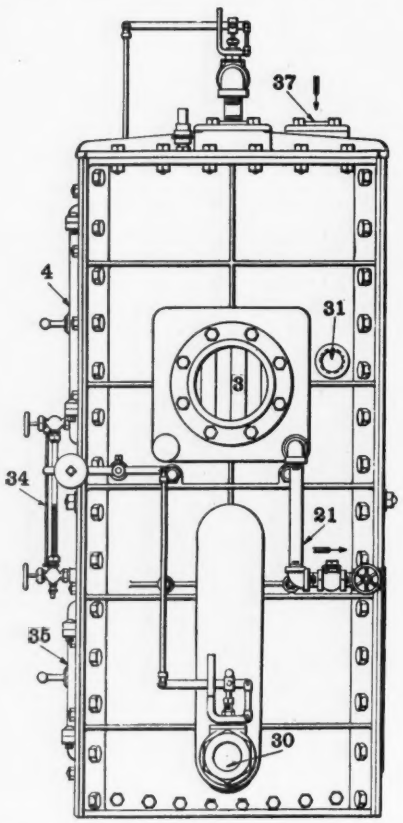
Exhaust steam enters through the separator near the top of the heater, passes into the heating chamber and out at the exhaust near the bottom at the other side of the heater.

WEBSTER FEED-WATER HEATER AND PURIFIER

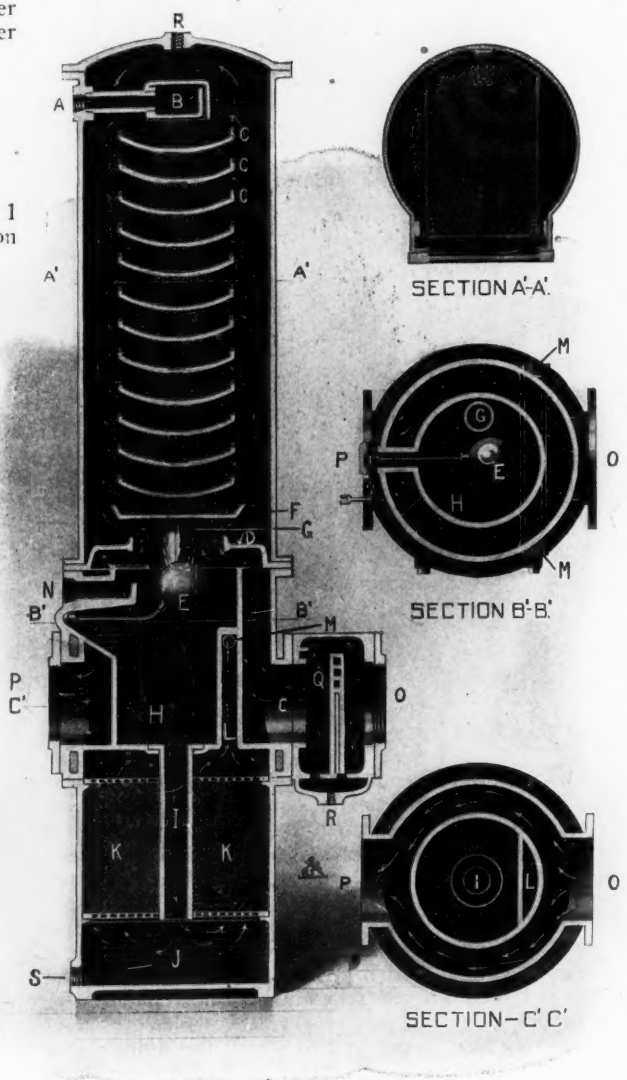
Warren Webster & Co., Camden, N. J.

The shell of this heater is of rectangular form, 1 style being made up of sectional plates of cast iron bolted and calked by a patented ventilated rust joint. Water supply to the heater is controlled automatically so that a constant water level is maintained within the heater. Entering the heater through the inlet valve, the water passes into the water-sealed distributing trough, which has a wide extended lip.

Flowing from this trough in an even sheet it is distributed over a series of oppositely inclined, finely perforated copper trays, arranged one above another so that the water in its downward course falls from one tray to another and any water which does not pass through the perforations will fall upon the protruding upper edge of the next tray. This arrangement retains the water in the heating chamber in a finely divided state until it has mingled with and been heated by the surrounding steam, causing a liberation of gases and precipitation of solids. After leaving the lower tray the water falls into the settling chamber below to reach which it passes through a down-take pipe to the under side of the filter. It rises upward through the cast-iron perforated screens, which hold the filtering material in place, through the filtering material and upper screens to the under side of the division plate whence it travels to the pump outlet. The filter bed is commonly composed of coke or other



WEBSTER FEED-WATER HEATER AND PURIFIER



ERIE CITY OPEN FEED-WATER HEATER

suitable materials. Beneath the filter bed, as stated above, is the settling chamber, from which the sludge is drawn off by means of the blowoff valve.

The steam supply is drawn up to the heater by a peculiar method through a branch from the main exhaust pipe with a gate valve in it. Before entering the heating chamber it passes through the oil separator, which is a series of hook-shaped baffle plates, the oil and entrained water being drawn off at the bottom.

ERIE CITY OPEN FEED-WATER HEATER

Erie City Iron Works, Erie, Pa.

The open feed-water heater now offered to the trade by the Erie City Iron Works is the outcome of a careful and exhaustive study of the subject. An especially designed inlet head and trays are used, and a deflecting plate is introduced in order that water that might come in contact with the side of the heater will not flow out through the overflow. Careful attention has been given to the design of an inlet valve and much of the success of the heater depends upon having an inlet valve that is right in every respect.

In this heater a reheating chamber is employed from which the feed water is taken to the boilers, and this reheating chamber is directly opposite, and in direct contact with the incoming exhaust steam as it enters the heater on one side, and with the water before it goes into the filtering chamber on the other side. In this way the reheating chamber is surrounded by the hottest water and steam in the heater. The result is that the water is reheated to the hottest temperature possible with exhaust steam and the heat lost in the process of filtration is restored just as the water leaves the heater, thus increasing the temperature from 6 to 10 deg.

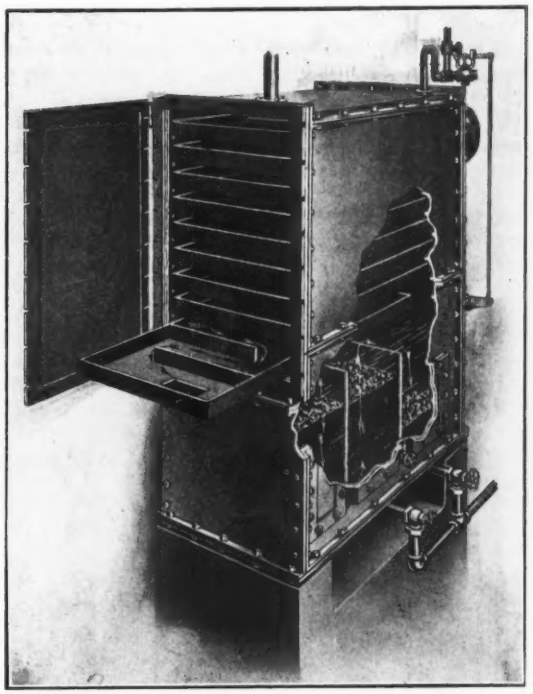
The illustration shows clearly the construction and operation of this heater and need no further explanation.

THE STICKLE OPEN COIL HEATER AND PURIFIER

Open Coil Heater & Purifier Co., Indianapolis, Ind.

These heaters are made with cast-iron flange plates perfectly machined and bolted together with steam cement in the joints sufficient only to fill the tool marks, and there are no rust, calked or leaded joints. The openings at front and side are made up with gaskets of tarred paper coated with graphite. The trays are made of cast iron, except the top one, which is of steel. The outer edges of the trays are higher than the partitions which are opened alternately at each end, causing the water to flow in a crooked course. Filter plates are removable through the front door. The oil separator and receiver is machined and bolted in the back end of the heater, and is connected to the overflow water seal leading to sewer.

Feed water enters the heater at the back end, controlled by an automatic float and balanced valve, travels four times across and the full length of the tray, passes to the next tray below through a hole in the bottom of the tray, continuing to do so through the several trays. The water travel in the twelve tray heater is approximately 132 ft. over tray surface, taking about 7 min. exposure to steam, which liberates the gases completely. Steam enters the heater by induction through the separator and receiver at the back end through oblong extended nozzle openings into the receiver which forms a part of the oil separating device, passing above and below each tray. A small vent pipe on the top of heater insures it against becoming air bound. The long travel of water over tray surface and time of exposure results in the complete separation of carbonates of lime and magnesia. The induction plan of the heater permits of complete oil separation, as 80 per cent of the exhaust steam is by-passed.

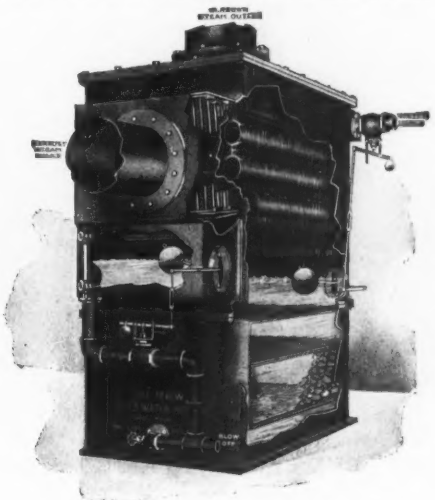


STICKLE OPEN COIL HEATER AND PURIFIER

LOEW OPEN TYPE FEED-WATER HEATER

Loew Mfg. Co., Cleveland O.

The Loew open type boiler feed-water heater is constructed of cast iron and brass, these metals having been found to resist the action of water and steam. All sizes from 50 to 800 hp. are built in one piece. Large sizes

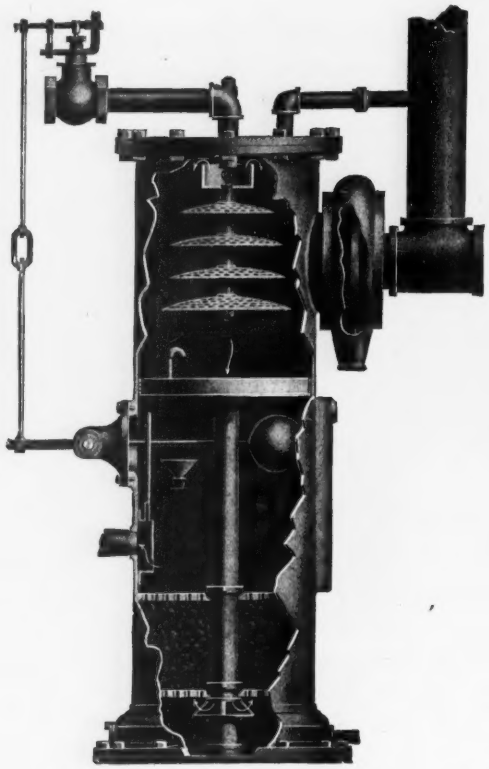


LOEW OPEN TYPE FEED-WATER HEATER

are built in sections strongly ribbed and bolted together at the flanges, and are made steam and water tight with rust joint calking from the inside. The upper part of the heater contains the heating tubes, through and around which the steam passes, and these are interchangeable and removable. The tubes are suspended from rods fastened to the top of the heater and bolted at the bottom, although for cleaning they can be quickly removed through the opening provided for that purpose.

The water supply is controlled by a balanced valve, which is connected to and operated by a specially constructed float, located in the heater. Above the heating tubes is a series of pipes containing the cold water, which flows through a slotted opening in each pipe and then drips over the heating tubes. The lower part of the heater consists of 4 successive horizontal chambers. Two of these compartments permit settling of the water before it reaches the filter bed, thus there is only a little sediment left in the water when it strikes the third or filter compartment, and its upward course here prevents the formation of scale over the surface of the filter.

Exhaust steam enters at the side through an oil separator into the upper chamber, exhausting from the heater through the outlets at the top. The oil separator is a part of the heater and consists chiefly of a series of V-iron baffle plates placed at an oblique angle and staggered in 4 rows, the collected oil being continually driven down by the incoming steam.

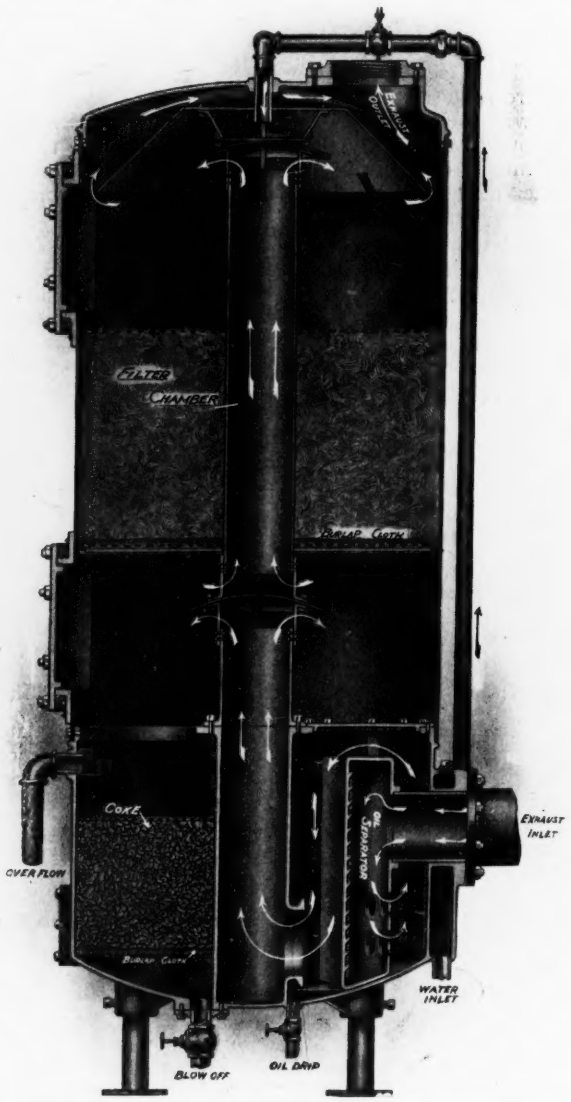


SIMS OPEN FEED-WATER HEATER

flow is secured. No effort is made to gather scale-producing matter at this point.

Only a part of the exhaust steam is used by this heater, entering through an oil separator passing into the heating chamber and out at the top to the main exhaust pipe.

The water passing through the automatic valve flows into the cup, the pipe being somewhat below the surface and forming a trap so that the steam cannot back up into the water line. The water overflows from this cup over the inverted perforated saucers, forming a shower as it passes from one to another, flowing into a receiving tray, down the pipe as indicated by the arrow, to the disk, which prevents the



MASSILLON FEED-WATER HEATER, PURIFIER AND OIL EXTRACTOR

SIMS OPEN FEED-WATER HEATER

The Sims Co., Erie, Pa.

Cast iron is used in the construction of these heaters, which resists corrosion as steel would not do.

Inverted perforated saucers are suspended from a bolt hook, and as this construction is always plumb, even when the heater is somewhat out of line, even agitation of the water in the mud chamber, affording the heavy particles of impurity an opportunity to precipitate. A suitable skimmer is used so that the surface of the water can be floated off at any time.

The pipe shown in connection with the trap over the first line is so arranged that if the water level is being drawn down it will give vent to suction and

break the current to the pump before the scum could be drawn into the pipe. A vent pipe from the filter chamber through the receiving tray prevents the possibility of the water chamber being air bound.

MASSILLON FEED-WATER HEATER, PURIFIER AND OIL EXTRACTOR

Russell Engine Co., Massillon, O.

The upper part of this open feed-water heater shell is made of steel, the head of cast-iron, while the base is made of cast-iron to preclude corrosion, which would occur with steel. A seamless copper float is used with connection stem, and stuffing box made of brass, to control the water supply. Perforated plates are placed near the bottom of the reservoir immediately above which an oblong opening with cover is provided. By removing the cover the coke filtering material can be raked out instead of lifting it to the door above. Also, perforated plates are placed at the bottom of the oil separating chamber to prevent the steam from disturbing the oil and condensation in its course to the outlet at the bottom of the chamber. Large cleaning doors are provided at each filter bed and for access to the lower chamber.

The steam on entering the heater passes through a water jacket, which encircles the base a distance coinciding with the space occupied by the oil separating chamber, into an exhaust box enclosed in the oil separating chamber, the back of which internally is provided with tongues or ribs for catching oil as the steam is dashed against it. From this point it is dashed through holes in the box against a galvanized stamped plate with tongues protruding pointing downward, which conducts the steam and remaining oil against the cooled walls of the water jacket. The oil coming in contact with the cooled plate causes it to separate from the steam and is conducted to the bottom of heater and outlet. The steam then passes over the exhaust and down to the outlet near the bottom, where it passes up through the exhaust pipe in the center of the heater, which is surrounded by water in the reservoir, to a point below the first filter bed, where its course is interrupted by means of the cone over the end of the pipe. This fills the cavity with steam, which enters the pipe again above the cone and is conducted through the filter to the top of the heater, where the end of the pipe is covered with a perforated cone which acts as a spray for distributing the water in the steam. Over this is an inverted pan designed to baffle the steam and change its course on its way to the outlet at the top of the heater.

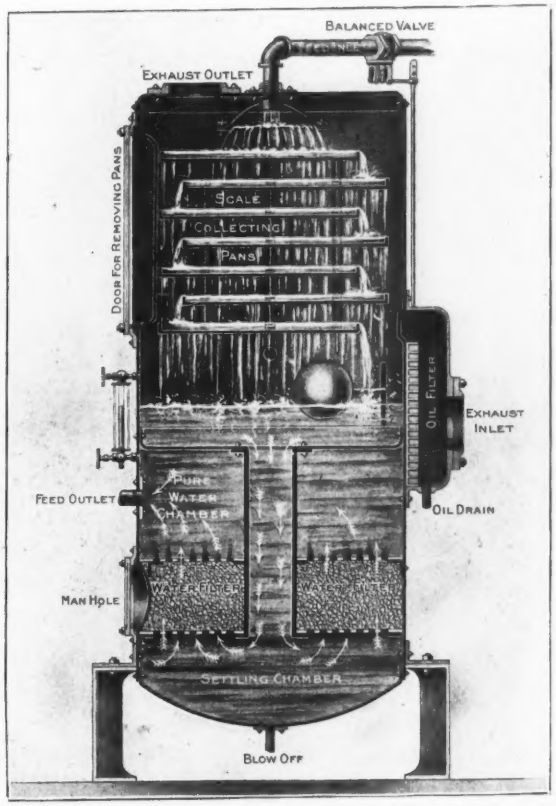
The feed water passes through the water jacket attached to the lower chamber and is conducted by means of a pipe to the top of the heater, in which pipe a balanced valve is located and is controlled by the flow connected to it. The water enters the heater at the center on top and is conducted down to the distributing cone on the end of the exhaust pipe, where it is broken up into fine particles and is heated as it descends to the excelsior filter chamber below, whence it falls on perforated plates and is evenly distributed over the filter bed. As it passes through this filter it deposits precipitates and other suspended matter.

At the bottom of the filter chamber are several thicknesses of burlap through which water must pass. It again falls in sprays through the steam to the top of the oil separating chamber and into the coke filter bed at the bottom of the heater. Passing through this filter to the bottom of the heater it goes through a large opening at the bottom of the pocket in which the float is located, then rises in this chamber to the suction outlet. Precipitates and sediment which are not caught by the filters will settle at the bottom of the heater and be blown off through the blowoff valve.

THE CASEY HEDGES OPEN FEED WATER HEATER, OIL SEPARATOR AND PURIFIER

The Casey Hedges Co., Chattanooga, Tenn.

This heater consists of an expansion chamber in which the scale collecting plans are located, a center or down-comer tube, through which the water passes after



THE CASEY-HEDGES OPEN FEED-WATER HEATER

it has left the pans, and a settling chamber through which the water passes from the down-comer tube, a filtration chamber, which is packed with charcoal, coke, excelsior or straw, and a pure water chamber, from which the boiler supply is taken.

The water passes through the inlet over the spray; from the spray it passes over the pans, coming in contact with the exhaust steam and is thoroughly heated as it passes over the pans to a temperature of from 200 to 208 deg., and at the same time the impurities are precipitated on the pans. When it leaves the pans it falls into the upper water chamber, then passes downward through the down-comer tube into the settling chamber, which allows for a precipitation of all matters held in suspension, half of the heater being a water reservoir. The scale pans can be easily removed through the opening at the side of the heater.

The head of the settling chamber is covered and at the bottom there is provided a blowoff through which all impurities can be removed. The next pass of the water is upward through the filtration chamber, which

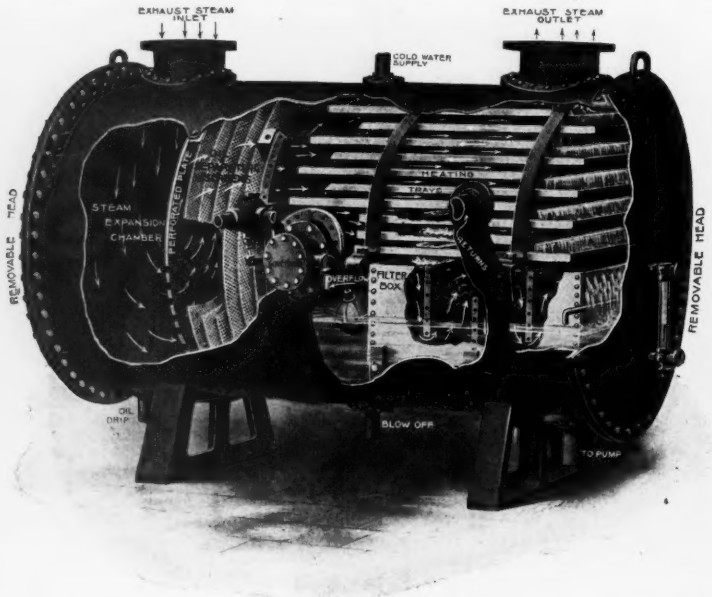
is composed of perforated sectional cast-iron plates that have interposed between them a suitable filtering material. The filtration chamber is packed through the manhole opening. The sectional plates are of such a size that they can be removed through the same opening and the heater cleaned both inside and out.

The water after passing through the filtration chamber passes through the pure water chamber, and then to the boiler feed pumps.

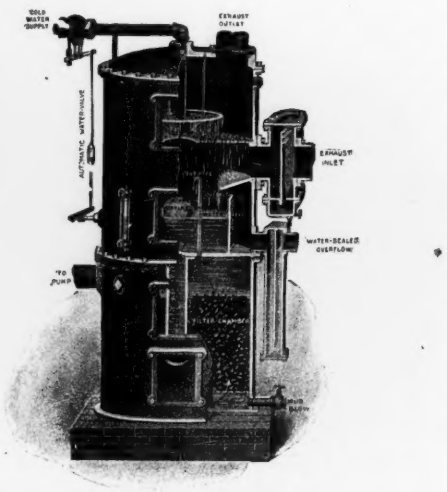
THE LINTON COMBINATION FEED-WATER HEATER, PURIFIER, OIL SEPARATOR, MUFFLER, RETURN TANK AND PUMP GOVERNOR

Linton Machine Co., 26 Cortlandt St., New York City.

A large section of this combined open feed-water heater is devoted to purifying the steam before it comes in contact with the feed water. The exhaust steam entering the large expansion chamber passes through the perforated plate to the wire mesh separating screens. A perfectly tight diaphragm prevents the liberated oil from coming in contact with the feed water. A large amount of heating surface is obtained by the use of shallow trays of large area, which completely fill the heating chamber. Hot water drips from the lower heating tray to the filter box, where it is compelled to percolate up and down through the entire length of this box. Any good filtering substance such as coke can be used and the box being on rollers may be easily taken out, when it is desired to renew the material, by removing the head at the end. The head on the other end is also removable, so the interior is readily accessible without disconnecting any piping. A governor controlled by a reinforced copper float has a very sensitive balanced valve and may be arranged to regulate either the steam for the boiler feed or the cold water inlet to the heater.



THE LINTON COMBINATION HEATER



WHITLOCK OPEN EXHAUST FEED-WATER HEATER

WHITLOCK OPEN EXHAUST FEED-WATER HEATER

The Whitlock Coil Pipe Co., Hartford, Conn.

The Whitlock open heater is a feed-water heater, purifier and filter combined. It consists of 2 cylindrical cast-iron shells bolted together, forming an upper or heating chamber and a lower or filtering chamber. Each shell has a solid cast bottom and the top head is bolted on with a rubber gasket in the ordinary way. The cleaning doors are light and easily handled and so arranged that every part of the interior is accessible for inspection and cleaning. The filter space filled with filtering material is enclosed by perforated cast-iron plates, which are removable.

The water controlled by a balanced valve passes through the heating chamber in a spray, this being accomplished by perforated trays, then downward through a cast-iron pipe to the bottom of the filter chamber, where the heavier sediment is deposited under the lower filter screen and discharged through the mud blow. From this point the water passes upward through the filter to the hot water chamber above the upper screen, thence to the pump suction. The filter may be flushed out by opening the mud blow and admitting water at a special connection in the hot water chamber, thereby reversing the circulation. The surface water should also be drawn off occasionally by holding the inlet valve open until the level rises above the overflow. The exhaust steam enters through an oil separator into the heating chamber and is exhausted to the atmosphere through the opening at the top of the heater.

MONITOR PURIFIER AND OIL EXTRACTOR

Jarvis Engine & Machine Works, Lansing, Mich.

This is of the pan type having circular cast-iron pans, the lowest of which rests on lugs riveted to the shell and supports those above it. Circular nozzles allow the passage of water and steam and to facilitate handling, each pan has 2 steel handles.

Water enters near the top of the shell, fills the top pan and overflows successively to all below, finally falling to a filter bed and passing through to the settling chamber below. The filter bed rests on a perforated plate and can be changed in a few minutes through the door at the front. Water for the pump is taken at some distance above the lower head, which is

dished to form a settling chamber and has a blowoff outlet at the lowest point.

Steam enters below the lowest pan through the Monitor oil extractor, passes up through the openings in the plates and that which is not condensed goes out on the opposite side near the top. The flow of water is controlled by a large float placed inside the shell and connected to the water inlet valve. Pans are removed through the top for cleaning by taking off the top cover.

The oil extractor is circular with corrugated and perforated baffles to catch the oil and carry it to a settling chamber at the bottom.

ECLIPSE OPEN FEED-WATER HEATER

Eclipse Feed-Water Heater & Purifier Co., Oshkosh, Wis.

The Eclipse open feed-water heater is a simple device for heating and purifying the boiler feed water. It is equipped with 3 sets of sediment trays of large area, which can easily be removed and cleaned, for they are constructed in sections. For cleaning purposes, the heater is accessible through 3 manholes, reaching every part of the machine.

The coke chamber acts as a further filter which takes up any of the sediment overflowing from the trays.

If desired this heater is constructed with an oil separator attachment, which will remove practically all the oil in the exhaust steam from the engine and will leave the steam upon entering the heater in such a condition as to be harmless as feed water for boilers.

COOKSON FEED-WATER HEATERS

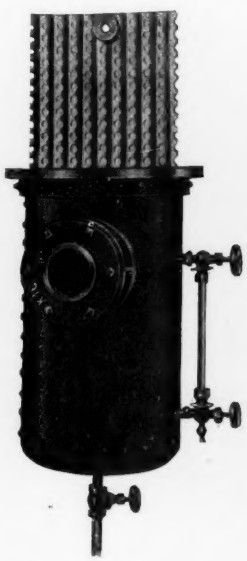
Bates Machine Co., Joliet, Ill.

This apparatus for the purifying, filtering and heating of feed water is of the open type, constructed of cast iron or steel plate. Exhaust steam entering at the side strikes V-shaped oil separating plates, which divide the volume of steam. The ribs on these plates catch the oil and moisture in the steam and drain them to the oil discharge pipe, while steam enters into the enlarged part of the exhaust pipe, where it passes into the opposite expansion and oil separating chamber and discharges to the atmosphere.

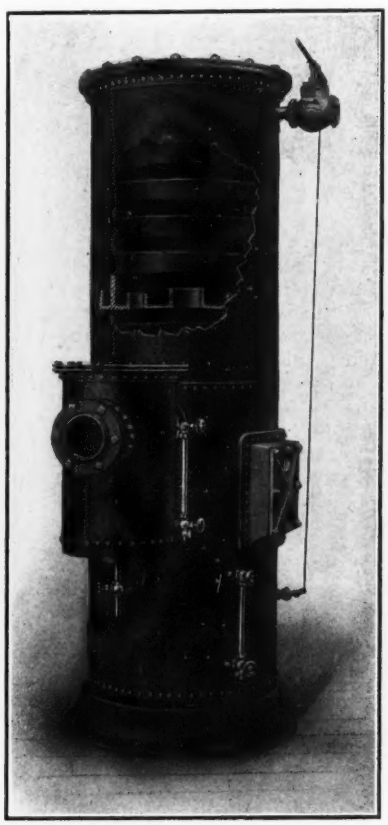
At the top of the heater is a vent pipe for carrying out air and gases released from the water in heating. The cold water supply entering in a spray condenses the steam, forming a vacuum, which draws the required amount of steam to heat the water up the large tube in the center. The valve controlling the water supply is operated automatically by means of a water regulator.

From the spray box at the top the water overflows to the pan below, overflowing successively from pan to pan until it reaches the one at the bottom, which is bolted to the top of the exhaust tube. These pans catch the lime deposit and are easily removed through the door at the side. From the last pan the water, having been heated, enters the lower portion at the back of the exhaust tube, and discharges from the hollow partition near the front into the filtering chamber below, where the remaining impurities in suspension are removed by filtration.

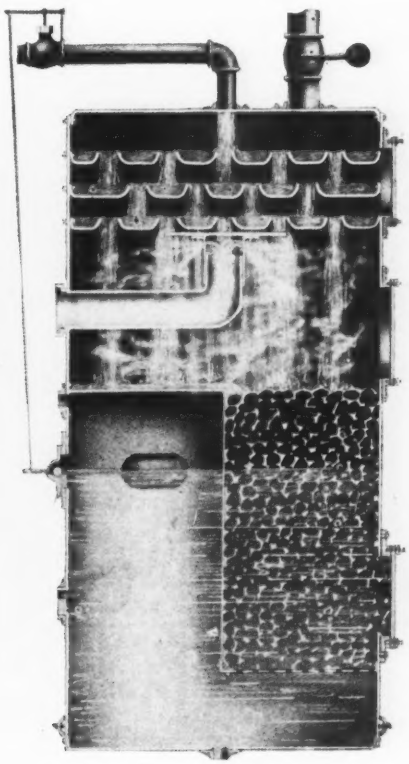
The filtering chamber is filled with coke or excelsior, and at the back of this chamber is a perforated plate



OIL EXTRACTOR SHOWING ONE BAFFLE PARTLY WITHDRAWN

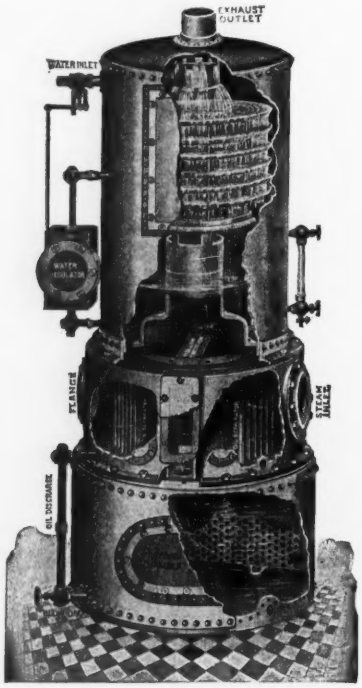


THE MONITOR PURIFIER AND OIL EXTRACTOR



ECLIPSE OPEN FEED-WATER HEATER

through which the water is drawn to the boiler. The sludge is drawn from the bottom of the settling chamber through the blowoff valve.



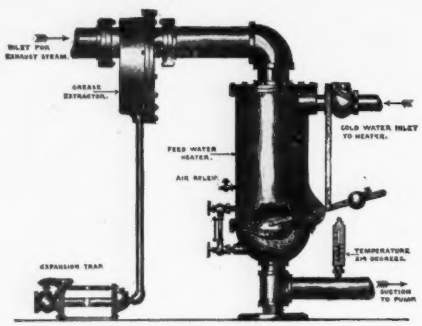
COOKSON FEED WATER HEATER

THE KIELEY COMBINATION PURIFIER AND FEED-WATER HEATER

Kieley & Mueller, New York

The combination of feed-water heater and purifier, here illustrated, consists of an oil or grease extractor and a heating compartment in which exhaust steam and feed water are brought into direct contact. Exhaust steam is drawn into the heater by induction through the grease extractor, which consists of a series of baffle plates, allowing sufficient area for the steam to expand and pass on without causing back pressure.

The feed water enters through the automatically-controlled inlet valve and is spread through the heating chamber, thus coming in direct contact with the steam which heats it to a high degree, and falling to the reservoir at the bottom, is drawn to the pump through the suction pipe.



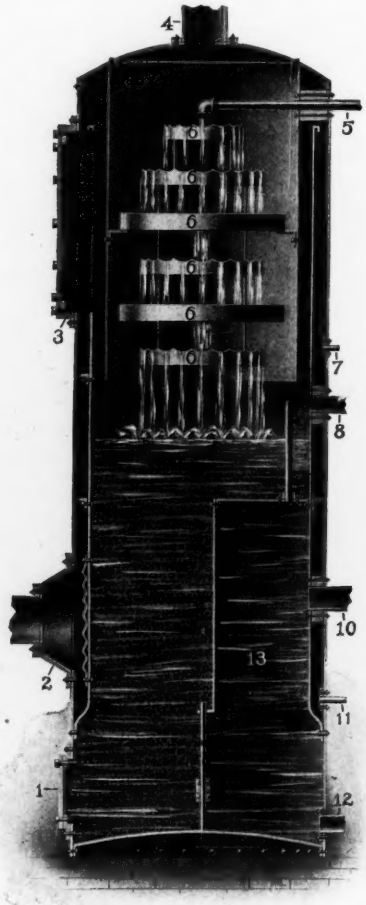
KIELEY COMBINED HEATER

CRAWLEY FEED-WATER HEATER AND PURIFIER

Manthey-Sieker Co., Milwaukee, Wis.

This open type feed-water heater purifies the water by precipitating the carbonates of lime and magnesia and then removing these, together with any substance that may be floating in the water, by passing the water through a filter. This is accomplished by supplying a large steam jacketed reservoir for the hot water, a cold settling chamber for the gathering of sediment, and a filter having a large surface. The water passes through the filter freely, but does not rush through the heater in a strong current. The filtering material is either coke or burlap, as desired.

The oil elimination in the Crawley heater takes place in a large steam jacket extending entirely around the heater. The steam jacket has a cubical capacity many times that of the steam inlet and, in addition, the path of the steam is intercepted by suitable baffle and corrugated plates. Exhaust steam entering at the inlet, 2, passes around and jackets the settling chamber, and up to near the top of the heater, where it is again deflected, passing down around the heating compartment, then up through the central part of the heater, surrounding the trays and coming in direct contact with the feed water. Thence it passes through the exhaust pipe, 4.



THE CRAWLEY OPEN HEATER

ECONOMIZERS

The economizer is designed to utilize the waste heat in the gases escaping from the chimney. This heat is used in most cases for warming the feed water for the boilers, but the apparatus is not called a feed-water heater for it does not use steam, either live or exhaust. Other important uses for this hot water are boiling, washing, and dyeing in textile and paper mills, and the heating of factories by the hot-water system. The advantages derived from the heating of water by the waste gases may be divided into 2 classes,—the saving resulting from the recovery of waste heat, and the effect on the boiler itself.

By heating the feed water from the waste gases a saving of from 10 to 20 per cent in fuel may be had, because when hot water is fed to the boiler a smaller number of heat units are necessary to convert it into steam. Additional saving comes from the more perfect combustion due to the high temperature maintained at all parts of the boiler. The addition of an economizer to the boiler plant is in the nature of increasing the heating surface, and higher efficiency is obtained because the water may be heated by gases which have been cooled to a degree impossible in a boiler. Further extraction of heat from the gases must be secured by additional but separate heating surface.

The advantages from the viewpoint of the boiler itself are as follows: The introduction of hot water greatly prolongs the life of the boiler by reducing to a minimum strains due to sudden expansion and contraction. By eliminating the feeding of cold water all parts may be kept at a constant high temperature. It is a well-known fact that water heated to about 250 to 350 deg. precipitates a large proportion of the impurities. In the case of the economizer the impurities are deposited in the wall box where the sediment may be blown out easily, and therefore the boiler itself steams more freely and efficiently, and need not be blown out so frequently. The feeding of hot water reduces the expense of repairs, for with the constant high temperature the number of leaks is a minimum. Again, with the economizer, a large quantity of hot water is always ready to enter the boilers so that in case of sudden demand for more steam the boilers can meet the emergency with a minimum of forcing.

The amount of water that will be heated by an economizer depends, of course, upon the number of degrees through which each pound is to be raised and the size of the plant. Each installation must be specially considered and, therefore, it is impossible to give definite figures and expect them to apply to all plants. In general it may be said that the economizer heating surface is 4 to 5 sq. ft. per boiler horsepower.

There are really 2 ways in which the economizer may be applied. It may take the cold feed water, about 60 deg., and heat to 200 or more deg., or, as is more frequently the case, the feed water first passed through a feed-water heater in which the temperature is raised to a point varying from 125 to 210 deg. It then goes to the economizer where it is still further heated to, say, 350 deg. In an installation of this kind the water enters the boiler at a temperature practically equal to that of steam at 150 lb. pressure; thus the boiler is not called upon to heat the feed water but simply to convert it into steam. In other words, the boiler does not perform the function of a feed-water heater, but that of a steam generator, simply transmitting to the heated water the latent heat necessary to convert it into steam.

What may be expected of the economizer depends upon the volume of waste gas, its temperature, and the amount of water to be heated. If a small quantity of water is to be heated, a moderate-sized economizer will heat it to a high temperature, while the same economizer, with the same waste gas, would heat a greater weight of water to a moderate temperature.

In average power plants, such as those connected with industries such as paper manufacturing and textile mills, the feed water is heated about 100 deg., while the waste gas is cooled about 200 deg. Five tests in which the feed was heated in a feed-water heater before going to the economizer gave the results shown in the table.

RESULTS OF ECONOMIZER TESTS

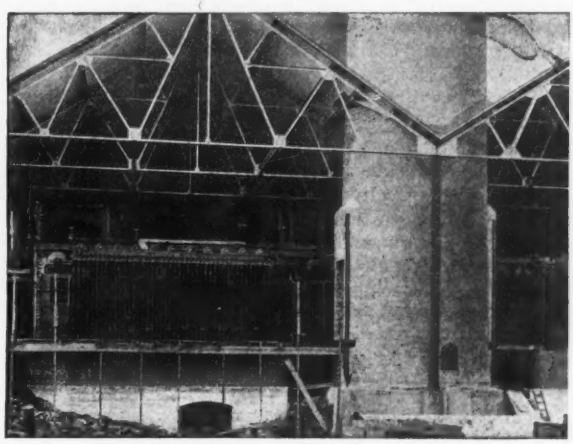
NO.	WASTE GAS			WATER		
	INITIAL	FINAL	DIFF.	INITIAL	FINAL	INCREASE
1	400	185	215	120	210	90
2	530	300	230	130	245	115
3	350	220	130	120	190	70
4	480	240	240	90	210	120
5	380	180	200	76	170	94

Averaging these results we find that reducing the temperature of the waste gases 203 deg. raises the temperature of the water 98 deg.

THE STURTEVANT ECONOMIZER

B. F. Sturtevant Co., Hyde Park, Mass.

The Sturtevant economizer is made of a bank or stack of cast-iron pipe arranged in rows, the apparatus being placed between the boilers and the stack or chimney. The tops of all the pipes of a row are connected by a top header, and all the other ends are connected by a bottom header. The economizer is made up of a large number of these rows, the number depending upon the size of the plant. The bottom headers are connected on one side to the wall box which runs at right angles to the headers. At the top a manifold connects the top headers, thus completing the circulation.

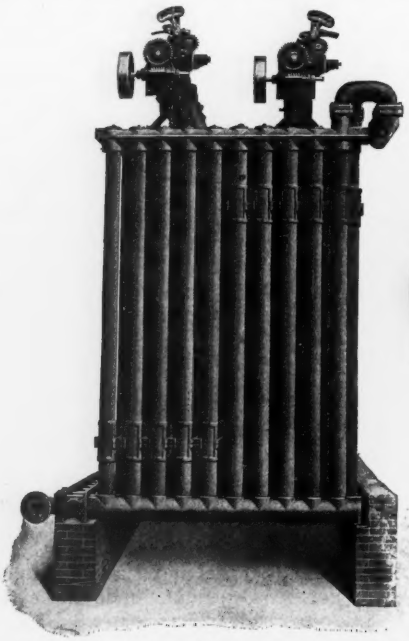


STURTEVANT ECONOMIZERS AT BETHLEHEM STEEL CO.

With what is called "forced circulation" the water enters at the bottom and flows up the pipes of a given number of rows, 4, 8, or 12, and then down a similar number of rows to the bottom headers and wall box. This flow is continued until the water reaches the other end of the economizer. The hot gases from the uptake of the boilers are conducted among and between the pipes which transmit the heat to the water. The cold water enters the end of the economizer nearest the stack, where the gases are cooled, and leaves at the end nearest the boiler, where the gases are at the highest temperature.

In order that the heating surface of the pipes may not become covered with a thick coating of soot, which

would soon prevent the free passage of heat, each pipe is provided with a scraper which moves continually up and down, the sharp edge keeping the pipes clean. The scrapers are arranged in groups and are held in place by scraper guards, and the scraper guards and scraper bars are raised by a chain which passes over a sheave. A group

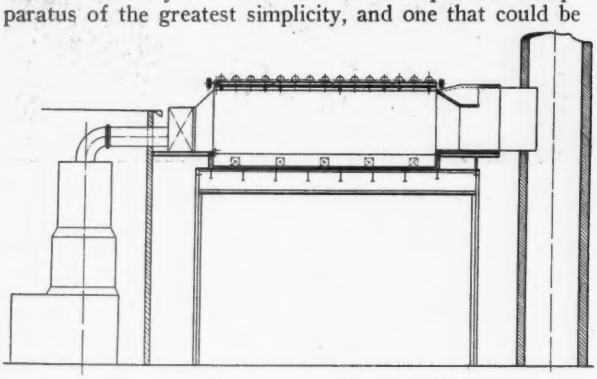


END VIEW OF STURTEVANT HIGH-PRESSURE ECONOMIZER

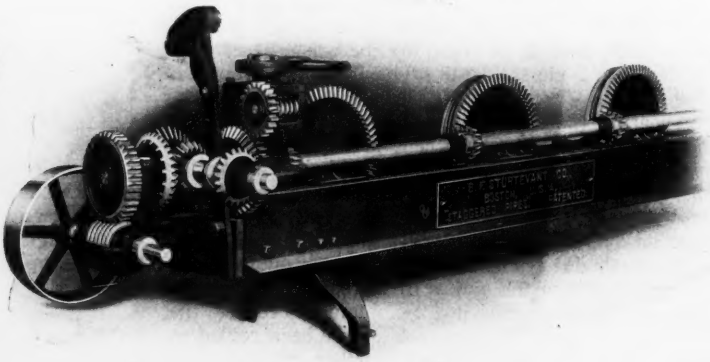
of these sheaves are revolved by suitable mechanism which connects with a pulley to which a belt runs from a small engine or motor.

The scraper mechanism, while having the appearance of complication, is, in fact, very simple, and the reversing arm is so arranged that the scrapers cannot stop while the belt is running. In other words, the action becomes positive when reversal takes place by the weight which suddenly swings to the next position.

In the design and construction of the Sturtevant economizer every effort has been made to produce an apparatus of the greatest simplicity, and one that could be

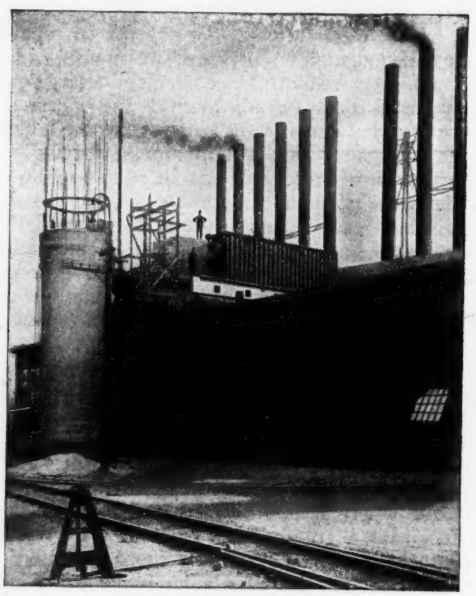


easily repaired should repairs become necessary. In an apparatus like an economizer a large number of joints are absolutely necessary, but in the Sturtevant type these have been made as few as possible. Constant increase of steam pressure has made it desirable to do away with the joints formerly satisfactory for low pressures, so that now all Sturtevant joints are made metal-to-metal, and they are steam tight with working pressure up to 300 lb. without a gasket or without rusting, as was formerly the practice. With the Sturtevant joint the ends of the pipes and the fittings are formed into a taper cylinder, which enters the taper hole. By setting up on the bolts the machined surfaces come in close contact; as these joints are metal-to-metal they are easily taken down.



STURTEVANT SCRAPER MECHANISM

The ease with which the Sturtevant economizer is repaired in case a leak is discovered is apparent to the engineer and mechanic who considers the shape of the pipe ends and the metal-to-metal joints. With the Sturtevant pipe the taper is parallel at the top and bottom, but the diameters are larger at the top, therefore, when a cap is removed the pipe is readily drawn up through the top header without disturbing any other pipe, header, or fitting. The new pipe can then be dropped in place and



INSTALLATION AT THE WOOSTER PLANT OF THE AMERICAN STEEL AND WIRE CO.

driven home, and the cap replaced in a very short time.

In case the bottom header cracks it is not necessary to break the connection of the top header, for all the pipes in that row may be drawn out of the bottom header without disturbing any other row. The bottom header may then be disconnected from the wall box and dropped

into the soot pit, as the side wall is outside of the bottom header. No brick work need be removed, and, therefore, it is not necessary that a mason assist in the repairs of the Sturtevant type. The new bottom header may easily be put in position, and after shoring up both top and bottom headers the pipe may be driven in place.

THE GREEN FUEL ECONOMIZER

The Green Fuel Economizer Co., Matteawan, N. Y.

This consists of a series of vertical cast-iron pipes 4⅝ in. external diameter and 9 ft. in length, which are made up in sections of various numbers of pipes to fill out any desired width. Any number of sections can be assembled to make the economizer of any desired length.

The tubes are pressed into top and bottom headers so that they stand in even rows in both directions. Staggered rows have also been used, but it is found that in a great many plants there is not enough draft to permit of this, while the advantages are largely problematic.

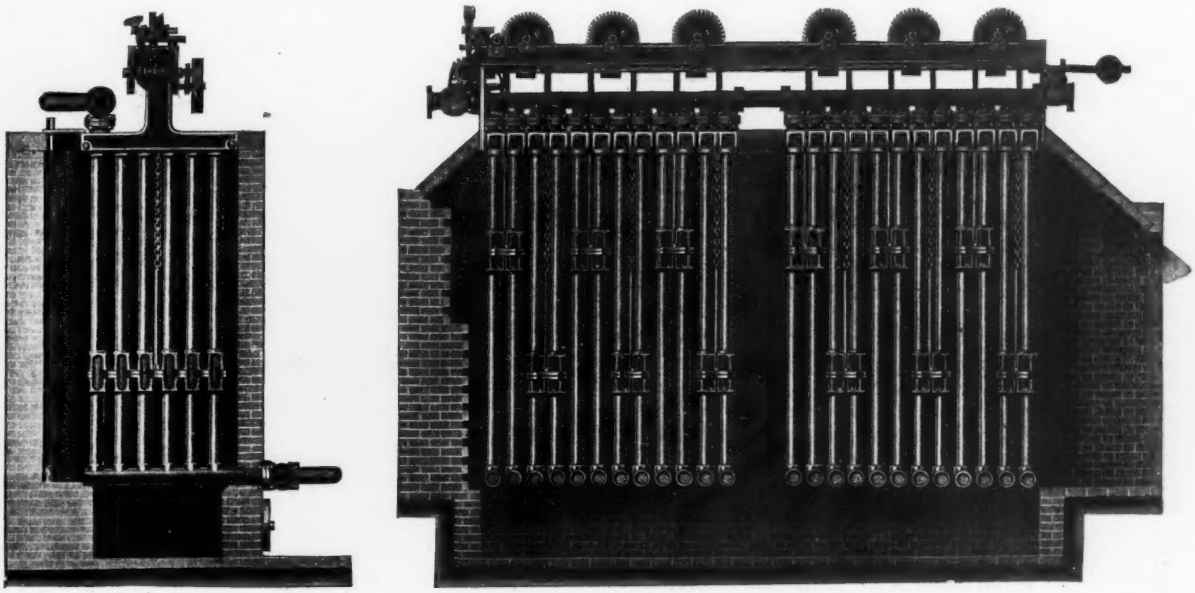
The bottom headers are connected at one side with the branch pipe running along the ends of the bottom headers outside of the economizer chamber. At the diagonally opposite corner the top header connects with another branch pipe, similarly located outside the economizer chamber. Connections to the branch pipes are made by means of gasketed joints, which not only insures tightness, but also gives the slight amount of elasticity required to take care of strains caused by uneven expansion and contraction of the different sections. As the gasket is not subjected to the chimney gases, and is in plain sight, deterioration and leakage are avoided. The hot chimney gases are led to one end of the economizer chamber, pass in among the pipes and escape considerably reduced in temperature and volume at the other end, after circulating among the tubes.

By-passes and dampers are usually provided for laying the economizer off while the boilers are in use. The feed water is usually forced by a boiler feed pump or injector into the economizer through the lower branch pipe, entering at the end of the economizer where the cool gases leave. The water then passes from the bottom headers up through the pipes into the top header and into the upper branch pipe, leaving at the end of the economizer where hot gases enter.

In order to keep the outside of the tubes clean of soot scrapers, driven by an automatic gear placed on top of the economizer outside of the chamber, pass slowly up and down. The soot thus removed from the tubes falls to the bottom and through into the soot chamber; the bottom headers in the Green fuel economizer being of a specially narrow form, which leaves sufficient room for the soot to fall through or even for the entrance of a man's arm for the replacement of scrapers. etc. The soot chamber is sometimes provided with an automatic cleaning arrangement driven from the same source of power as the scrapers.

In order to give access to the inside of the economizer, hand-holes are provided in the bottom access pipes, one opposite each bottom header, also in the top headers, one opposite each pipe. The handhole plates in the top headers are conical, and fit internally so that they are held tight by the pressure of the water. One of the plates of each header is made specially large to permit of the removal of the others. All joints within the economizer chamber are metal-to-metal, no gaskets or packings being used.

The most recent improvement in the economizer is the use of a sectional covering to replace one or both of the brick side walls, this covering being made of a substance which retains the heat better than the brick and does not crack or leak. Furthermore, it can be taken down in sections for cleaning and inspecting the tubes. The covering consists of 2 iron sheets with mineral wool or asbestos between, and with the edges stiffened by angle iron. The economizer is provided with blowout valves, safety valves, means for washing out the tubes and headers, and means for scraping the tubes and cleaning out the soot chamber.



THE GREEN FUEL ECONOMIZER, SIDE AND END VIEWS

ONE SQUARE FOOT of grate surface will burn 10 to 12 lb. of coal an hour.

INCREASING THE LAP on a valve lessens the lead, makes admission later and cutoff earlier.

FEEDING THE BOILER

THREE general methods are employed for feeding boilers, first by the use of pumps, second by injectors, third by the use of return traps. Each method has, of course, its advantages. The pump and the injector are the most common methods at the present time, but as an agent for the economic handling of condensation in steam lines and feeding boilers from open heaters at high or low pressure the return trap merits the attention of the power plant designer and manager, and particularly of the engineer in charge. The return trap may be adapted to feed the boiler from an open or closed heater, to return the water of condensation from a heating system directly to the boiler, regardless of the temperature of the water, to drain exhaust lines and vacuum oil separators without impairing the vacuum, to discharge high or low pressure condensation into a vacuum line and under all these conditions it should give good satisfaction. The steam pump uses a large amount of steam but the exhaust from the pump may be used in heating feed water and is, therefore, not wasted. The power driven pump uses much less steam per horsepower hour, as it is driven from the main engine. A comparison of cost given by a prominent pump manufacturer shows that with the triplex power pump run by belt from the line shaft, the horsepower at the pump pulley would be secured for about 20 lb. of steam per horsepower hour, and a pump requiring 7.5 hp. to run it will use 150 lb. an hour, equivalent to about 15 lb. of coal burned. The best to be expected from a direct-acting steam pump is from 125 to 150 lb. of steam per horsepower-hour, or if the pump required 7.5 hp. to operate it, this would require 950 lb. of steam, equivalent to 95 lb. of coal an hour. Against this must be put the convenience of regulating the speed of the steam pump to suit the demand for feed water and the fact already stated that the exhaust steam from the pump can be utilized.

In installing a pump it should be remembered that the practical lift of the pump is not nearly the theoretical lift. In theory a pump should lift about 30 ft.; in practice it will seldom go up to more than 20, and this height will vary with the altitude. At sea level the practical suction under the best conditions is 25 ft.; for half a mile above sea level, 23 ft.; a mile above sea level, 20 ft.; 2 miles above, 17 ft. When working in high altitudes this fact must be taken into account.

Pumps for boiler feeding have a ratio of diameters of cylinders steam to water of about 1.25 as a rule, this surplus being sufficient to force the water into the boiler unless there is a great amount of piping.

To find the horsepower in the water end of a pump, multiply the area of the water cylinder by the water pressure and by the piston speed in feet per minute and divide by 33,000; or to find the horsepower developed in the steam cylinder multiply the area of the steam cylinder by the steam pressure and by the piston speed in feet per minute and divide by 33,000.

In proportioning piping for pumps, the area of the suction pipe should be such that the velocity of the water will be not over 200 ft. per minute. This is on the supposition of a short direct suction pipe. If the pipe is 50 ft. long the velocity should be 180 ft. a minute, for 100 ft. long, 150 ft. a minute, and for 150 ft. long 125 ft. a minute. The rule for finding the area of the suction pipe is to multiply the area of the cylinder in square inches by the piston speed in feet per minute, and divide by 200. This gives the area of the suction pipe in square inches. The same rule may be applied for the delivery pipe except that the velocity may be 350 ft. a minute.

When pumping hot water the lift that can be obtained at a temperature of 200 deg. is 8 ft., since for the lift above this the vacuum will be sufficient so that the water will be changed into vapor. For this reason it is usually better where the water is over 190 deg. to have it come to the pump under a head.

In the water end of a pump it is better to have a large number of small valves than a few large ones. The combined area of the ports should be 30 to 50 per cent of the piston area.

In the air chamber, which is used to prevent shock, the volume should be from 2 to 3.5 times the volume of the water cylinder, if it is a single cylinder pump. If it is duplex the air chamber volume should be 1 to 2.5 times the water cylinder volume. The diameter of the air chamber at the neck should be not over 1/3 the diameter of the chamber proper.

The water piston of a pump when used for cold water is usually packed with some kind of a soft packing put in in the form of rings, in a recess left in the piston and held by a follower plate. Sometimes, if the pressure is not high a series of shallow grooves are cut in the outer surface of the piston and these serve to carry rings of water which prevent the flow between the two ends of the water cylinder.

In the case of hot water the pistons are packed by metallic piston rings similar to those on steam pistons. Occasionally the water groove is used for a hot water pump.

When the soft packing is used the piston packing should be kept always in good condition with the depth such that the rings will fit the barrel snugly but without extra friction; this means that the rings should be cut so as to be from ⅛ to 3/16 short of meeting when first put in. It is better to get these rings ready cut from the manufacturer, as it will save a great deal of work and insure smooth operation.

For packing the stuffingboxes of pumps it is better to use a number of narrow rings instead of a few wide rings. The stuffingboxes are usually shallow and if several rings are used those near the gland, which will soon become dry and hard, may be removed and replaced by new ones without taking out all the packing. The rings should be put in one at a time and pushed firmly to the bottom of the stuffingboxes with a piece of soft wood. The amount of pressure to be put on by the gland depends, of course, on the kind of packing, and for the best information on this the reader is referred to the December, 1908, issue of PRACTICAL ENGINEER.

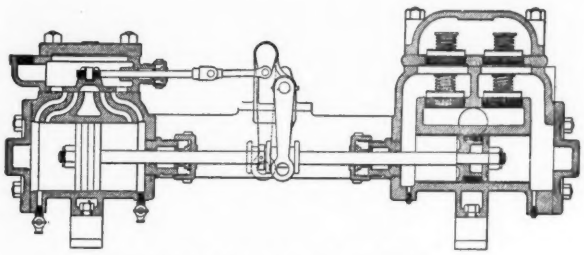
Injectors use the full heat value of the steam but cannot be controlled as to the amount fed to the boiler and must work either full capacity or not at all. The double tube injector or inspirator can be regulated to a certain extent but not over a wide range. The injector also is not able to handle extremely hot water and it is usually inconvenient to force the water from the injector through a feed-water heater. There is, therefore, no means of utilizing the exhaust steam from auxiliary pumps or from the main engine when using an injector for boiler feeding.

The matter of boiler feeding by return traps is taken up in detail in another part of the issue, also the handling of returns from steam heating systems by the use of the steam loop.

BUFFALO DUPLEX STEAM PUMP

Buffalo Steam Pump Co., Buffalo, N. Y.

The sectional view illustrates clearly the construction and operation of the Buffalo duplex steam pump. It consists of 2 simple direct-acting pumps so coupled that the



BUFFALO DUPLEX STEAM PUMP

steam piston of one actuates the slide valve of the other. The operation is positive as the steam valves are never so placed as to close all steam ports at one time, and the pump can always be started by turning on steam.

The method of construction is such that the piston slows down at the end of each stroke, allowing the water valves to seat quietly, thus preventing valve slam and consequent wear. The castings are heavy and of the best quality of iron, and all parts other than these castings are of selected material of the best sort for the purpose for which the pumps are to be used. The water linings are of good, hard brass, as are also the valve seats and valve bolts. Levers, connecting links, etc., are of cast steel or malleable, as the case demands, and valves and piston rods of best rolled steel.

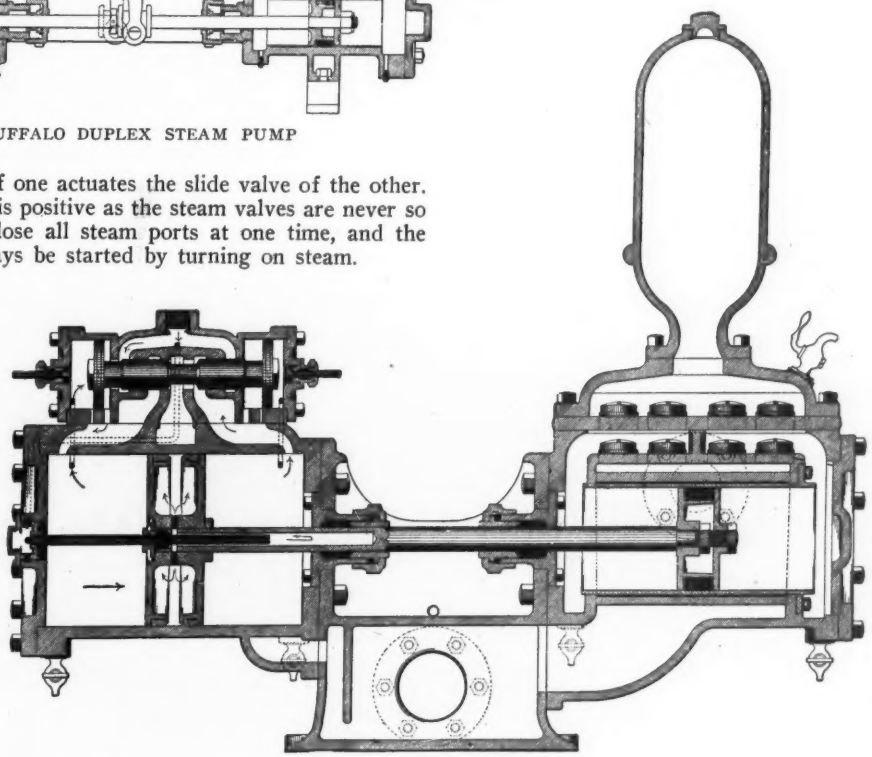
MARSH BOILER FEED-PUMP

American Steam Pump Co., Battle Creek, Mich.

Marsh pumps are especially adapted for handling feed water of the highest temperature, due to ample valve areas, small clearance spaces, positive length of stroke, and from the fact that they cannot race or pound, due to the governing feature of the steam valve. From the illustration it will be noted that piston cannot reverse until full stroke is made, as the center opening in the steam piston must come opposite the small drilled holes at each end of the cylinder.

The sectional cut shows the interior construction of the medium and large sizes of Marsh pumps. The direction of motion and steam currents are indicated by the arrows. Steam entering the chest is passing to the left through the annular opening formed between the reduced neck of the valve and the bore of the first head wall. It is thus projected against the inside surface of the valve head before escaping through the port and passing to the cylinder.

Both the pressure and impulse due to velocity acting on the valve head operate to close or restrict the admission port area at the annulus, by forcing the valve to the left or in the direction of the current. On reaching the cylinder and driving the piston towards the right the reactive effect of the cylinder steam upon the opposite side of the valve head, entering the outer end of the chest chamber, is pressing the valve toward the right, a movement which would give the admission port more area and deliver more steam to the cylinder. The valve then holds its position, depending upon the relative strength of the 2 forces which tend to move it in oppposite directions, admission steam which tends to close the valve and cylinder steam which tends to open the valve wider. This constitutes the governing element.



THE MARSH STEAM PUMP

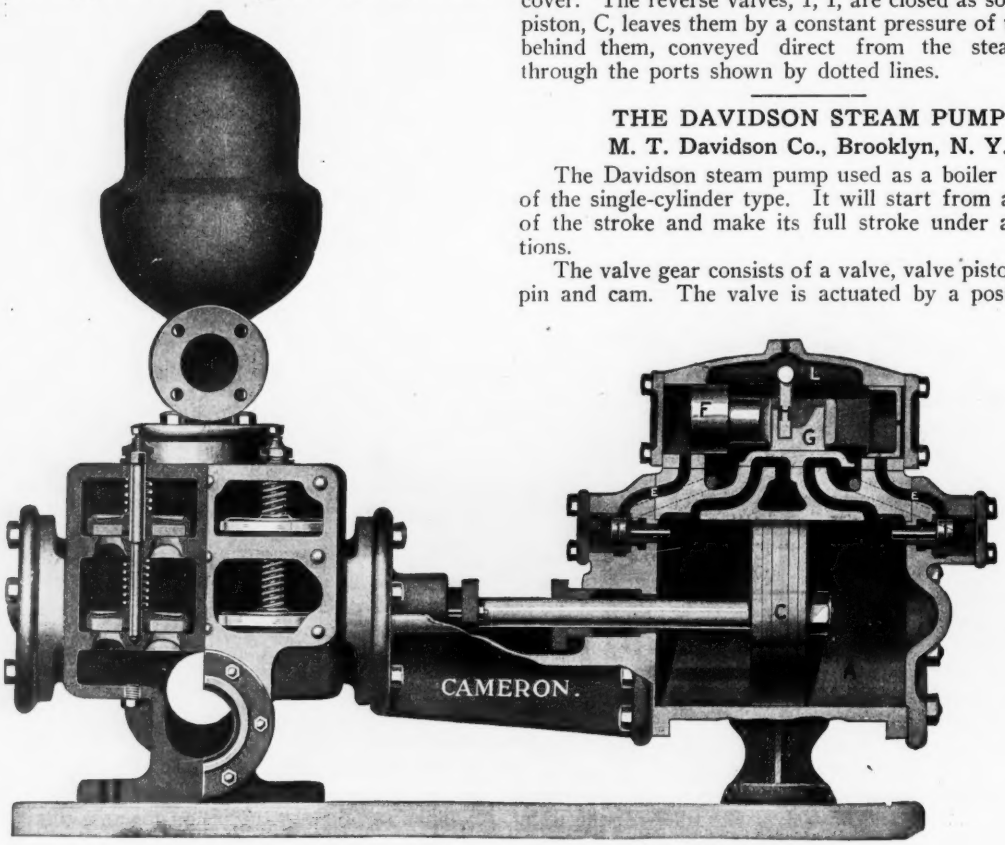
The steam piston is, as shown, of a spool form, each head of which is provided with metal packing rings; the interior space forming a reservoir for live steam, which is supplied from the upper chamber of the chest above the valve, following the passage indicated by dotted lines to the central cap in the cylinder cover through attached tube and hollow piston rod. This pressure is used only for the purpose of tripping or reversing the valve by admitting steam alternately against the outer surface of the valve heads through the connecting passages near each end of the steam cylinder.

CAMERON REGULAR BOILER FEED PUMP

A. S. Cameron Steam Pump Works, New York, N. Y.

All single, direct-acting pumps make use of an auxiliary plunger to carry the main slide valve which gives steam to the main piston, and by means of the various devices steam pressure is made to drive this auxiliary plunger back and forth. In the Cameron pump the plunger is reversed by means of 2 plain tappet valves, and the entire mechanism thus consists of 4 stout pieces only, all working in direct line with the main piston.

The illustration shows cross-sections of both the steam and water ends of this pump. The right-hand side of the water end is shown in full as it appears when the bonnet



CROSS-SECTIONS OF STEAM AND WATER ENDS OF CAMERON PUMPS

is removed and the left-hand side in section. By removing 1 bonnet or cover the whole interior with every valve is plainly visible. The holes for seats in the shelves are reamed out tapering, and the brass seats forced in and can thus be readily taken out and renewed at any time. Each stem holds 2 valves with their springs one above another, so that by unscrewing 1 plug and pulling up the stem both are released. The valve chest is located near to the base of the pump and close to the bore, which decreases the suction lift to a minimum. Every pump has 2 suction openings, 1 on each side, and the discharge opening can be turned in any direction desired.

C, the steam piston, is driven by steam admitted under the slide valve, G, which, as it is shifted backward and forward, alternately connects opposite ends of the cylinder, A, with the live steam pipe and exhaust. This slide valve, G, is shifted by the auxiliary plunger, F. The plunger is hollow at the ends and the chest, being filled with steam which, issuing through a hole in each end of the plunger, fills the spaces between it and the heads of the steam chest in which it works. Pressure being equal at each end, this plunger, F, under ordinary conditions, is balanced and motionless; but when the main piston, C, has traveled far enough to strike and open the reverse valve, I, the steam exhausts through the port, E, from behind that end of the plunger, F, which immediately shifts accordingly and carries with it the slide valve, G, thus reversing the pump. No matter how fast the plunger may be traveling it must instantly reverse on touching the valve I. In this movement the plunger, F, acts as a slide valve, to close the port E, and is cushioned on the confined steam between the ports and steam chest cover. The reverse valves, I, I, are closed as soon as the piston, C, leaves them by a constant pressure of the steam behind them, conveyed direct from the steam chest through the ports shown by dotted lines.

THE DAVIDSON STEAM PUMP

M. T. Davidson Co., Brooklyn, N. Y.

The Davidson steam pump used as a boiler feeder is of the single-cylinder type. It will start from any point of the stroke and make its full stroke under all conditions.

The valve gear consists of a valve, valve pistons, valve pin and cam. The valve is actuated by a positive mechanical connection with the main piston rod, and by the action of steam on the valve pistons. The illustration shows the valve gear and steam cylinder in detail. The steam chest consists of a cylinder, valve and valve piston. The pistons are connected, sufficient space being allowed between them for the valve and steam ports. The valve is controlled and operated by the steel cam, C, acting upon a steel pin, D, which passes through the valve into the exhaust port in which the cam is located. In addition to this mechanical operation steam is alternately admitted to and exhausted from the ends of the steam chest by the ports e and e′ operating the auxiliary pistons B and B′.

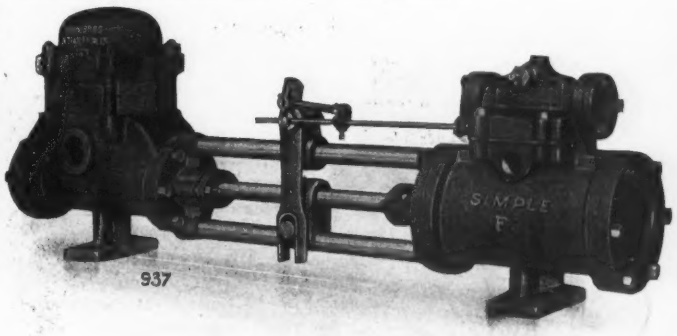
The pump being at rest with the valve A covering the main steam ports, f and f′, the cam, C, holds the valve by means of the valve pin, D, so that the ports, e and e′, admit steam to one end of the chest and connect the other end with the exhaust port. The steam acting on the valve pistons will move them, and the valves, opening the main ports, f and f′, admitting steam to one end of the steam

cylinder and opening the other end to the exhaust. If the valve occupies any other position the main ports, f and f', will be open for the admission and exhaust of steam.

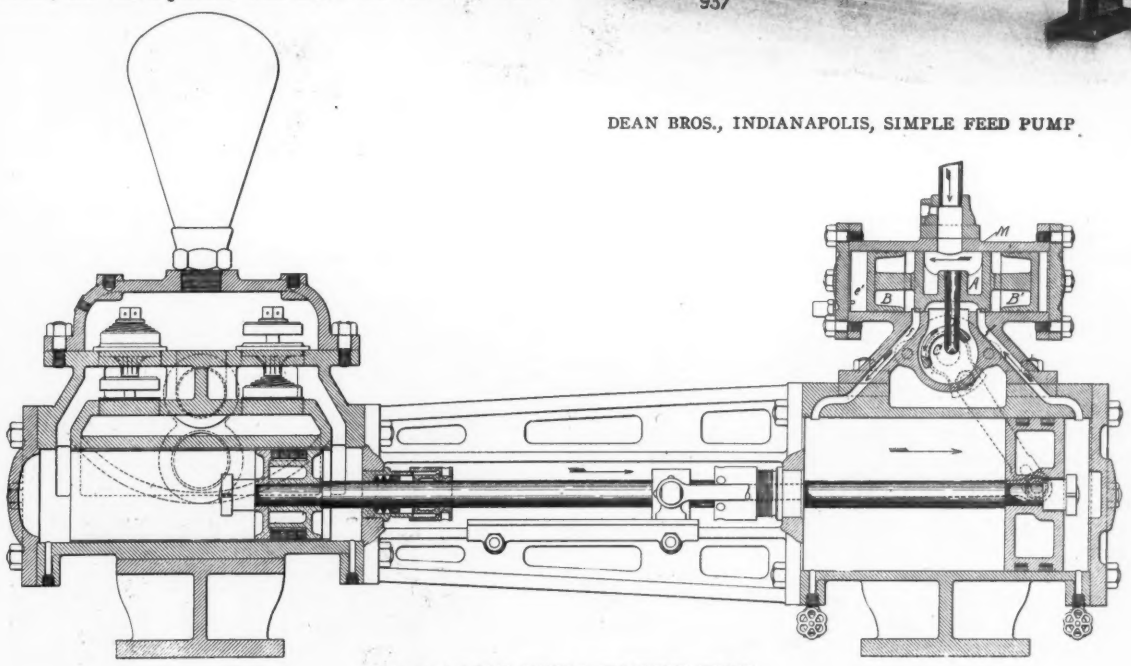
Steam being admitted to the cylinder by one of the main ports, as f in the illustration, the steam piston, cam, valve, etc., will move in the direction indicated by the arrows. The first movement of the cam will be to oscillate the valve preparatory to bringing it into proper position for the opening of the auxiliary steam port e to live steam and e' to exhaust, and the second to bring the valve to its closure, mechanically, slightly before the end of the stroke of the main piston, thereby causing slight cutoff and compression, and fully opening the auxiliary port e to steam and e' to exhaust. By the admission of steam to one end of the chest, the other being open to exhaust, the valve pistons will move the valve to such a position as will allow the admission and exhaust of steam to and from the cylinder for the return stroke.

The valve area in the water cylinder is liberal, making possible the high speed at which these pumps can be run without noise. The interior of the cylinder can be readily inspected by the removal of one or more plates or handhole bonnets without breaking suction or discharge pipe connections. The pistons are furnished with special packings to suit the service for which the pumps are intended. Cupped leather packings are used for cold water and square fibrous packing, set out by brass springs, for hot water.

The steam pipe is not screwed into the steam chest, but enters the steam cylinder below the chest, so that the engineer can, at any time, take the chest off without disturbing the pipes. The steam packing rings are automatically adjustable for wear and pressure.



DEAN BROS., INDIANAPOLIS, SIMPLE FEED PUMP.



THE DAVIDSON SINGLE-CYLINDER PUMP

DEAN BROS. SIMPLE PUMP

Dean Bros. Steam Pump Works, Indianapolis, Ind.

The frame of this pump consists of cast-iron heads connected together with steel rods in a vertical plane with the piston rod. All strains are longitudinal, and a light frame of extraordinary strength is made possible.

The water cylinders of these boiler feed pumps are designed to withstand a pressure of 500 lb. to the square inch, while the steam cylinders are built for a pressure of 400 lb.

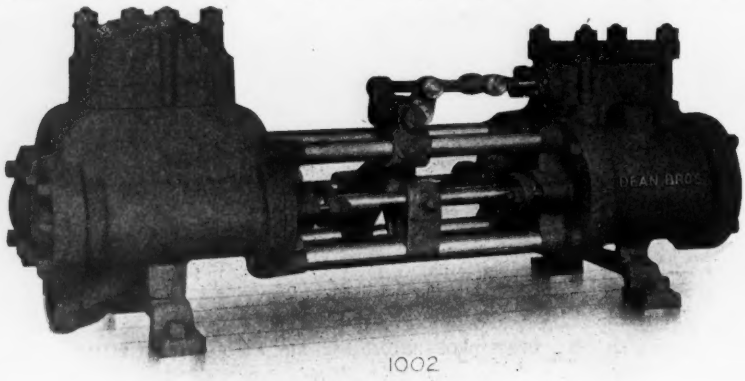
The water cylinder is made with removable air chamber and valve plate, this plate being extra thick to avoid springing and the blowing out of gaskets, or the leaking of water across the bridge that separates the suction valves. The stems of the suction valves project above the water cylinder so that they may be easily unscrewed. The valve seats and stems are of brass, while the valve disks are of rubber. The cylinder is reversible so that the openings for pipes can be reversed if so desired.

The piston is made so that either square, fibrous or metal packing can be inserted. The piston head is fitted to the rod on a taper, so that the rod and piston can be easily removed. The suction and discharge pipes enter the cylinder below the valve plate, so that the cover and plate may be taken off without disturbing any pipes,

The air chamber is in the water chest cover, the space for air being separated by a partition, so as to insure its being charged with air at all times. The valve gear is positive, simple and durable in its construction, both main and auxiliary valves having flat slides. The motion of the auxiliary steam slide is continuous. The ports leading to the chest piston are closed except at the moment the main piston is being reversed, hence there can

be no blow through or waste of steam in case the piston chest becomes worn. The stroke of the pump can be changed by moving the stud in the slot at the upper end of the lever.

Dean Brothers also manufacture pumps in duplex style. Other designs of boiler feeders made by them cover plunger pumps, vertical boiler feeders and pot valve pattern pumps, all in both single and duplex types.



DEAN BROS. DUPLEX PUMP

DEMING GENERAL SERVICE SINGLE-ACTING TRIPLEX PUMP

The Deming Co., Salem, Ohio

When used as boiler feeders the Deming pumps are driven by belt, motor, or direct connection to an engine. Deming triplex pumps embody the principle of the three-throw crank shaft with crank pins at an angle of 120 deg. apart, by which arrangement the strokes follow and overlap one another. This results in a continuous and uniform action upon the water being pumped, and insures an easy flow through the delivery pipes, with a corresponding high degree of efficiency in the operation of the pumps.

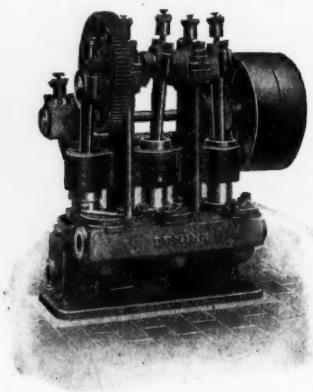
All of these triplex pumps have the plungers and crossheads outside guided, thereby relieving the stuffing-box glands of lateral pressure due to the side thrust of the connecting rod. The main housings or guide columns of these geared pumps are of the box girder type, and contain 2 bearings of extra large dimensions, which support the crank shaft between the cranks. By having 2 main bearings only, it is always easy to have them in line, and without perfect alignment it is obvious that the shaft will have to be sprung more or less during each revolution, with consequent loss in efficiency.

The crank shaft is made of open hearth steel in 1 piece, with all bearings of ample dimensions. On the end of the shaft is a large flange to which is bolted the main gear, this being accurately recessed to gage to fit this flange, by which arrangement there are no parts to become loosened or keys to give trouble. The valve chambers, except in the smaller sizes of pumps, are separate from the cylinders, and are bolted to them. They have large valve areas, and each group of suction and discharge valves are easily gotten at by removable handhole plates or covers. Suction and discharge connections may be made at either or both ends of the pump, thus making them adapted to almost any location.

GOULD'S POWER PUMPS

The Gould Manufacturing Co., Seneca Falls, N. Y.

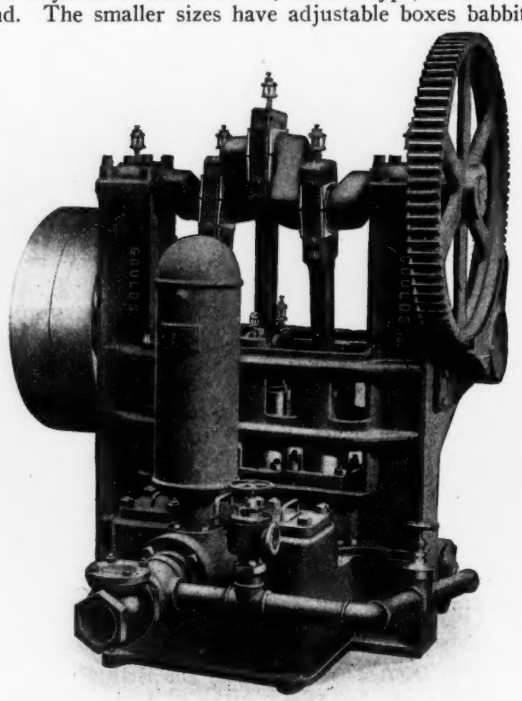
The construction of Gould's boiler feed pumps, as illustrated herewith, consists of a frame cast in one piece with crosshead guides and cylinders, which forms a rigid construction and accurate alignment of all working parts. The crank shaft is made of open hearth cast steel, and the crank shaft and pinion shaft bearings are of babbitt metal. Gears and pinions are of charcoal iron machine cut from the solid. The crossheads are fitted with adjustable bronze shoes, which run in bored guides. In the



THE DEMING SINGLE-ACTING TRIPLEX PUMP

smaller sizes the crossheads are cylindrical in form, made of bronze, and running in bored guides.

The connecting rods in the larger size are strap head and wedge adjustment, with bronze boxes at crank end, and adjustable bronze boxes, marine type, at crosshead end. The smaller sizes have adjustable boxes babbitted



GOULD'S TRIPLEX POWER PUMP FOR BOILER FEEDING

at crank shaft end, and bronze bushing crosshead end. The cylinders are of close-grained iron cast in one piece with standards. The plungers are of hard cast iron, with bronze plungers accurately machined and ground true and

smooth. The base of this pump is made of charcoal iron in one casting of liberal proportions, affording large valve area, direct water ways and easy access. For cold water rubber disks on bronze grid seats with cylindrically-wound springs are used. For hot water metal wing valves of bronze ground to seats are furnished.

For boiler feeding the pump is generally run at a fixed rate of speed for supplying the maximum demand of the boiler, while the actual requirements may vary. To allow for this variation a by-pass is used between the discharge pipe and the inlet side of the pump. By means of a gate valve in the by-pass the feed may be regulated to meet the requirements, the surplus water returning to the source of supply. An automatic relief valve should be used, adjusted to relieve at a pressure slightly above that carried on the boilers. These pumps can be fitted with by-pass known as Control K, which consists of gate valve, discharge check valve and piping, as shown in the view attached.

For handling hot water the pump should be fitted with bronze-lined cylinders and glands and bronze plungers. The pump should run at about 20 to 30 r. p. m. The object in this slow speed is to obtain slow plunger travel and prevent any possibilities of the hot water vaporizing, due to too fast plunger speed.

The pump should be placed well below the suction supply so that it will always be under flooded suction.

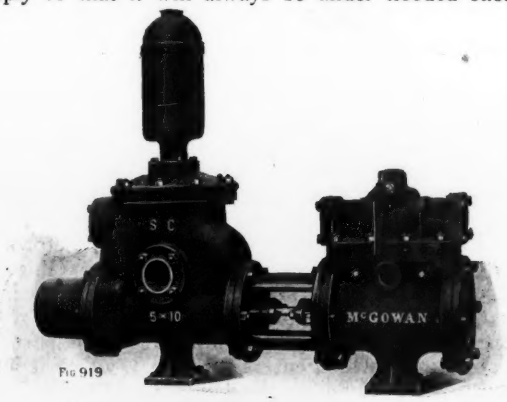


Fig 919

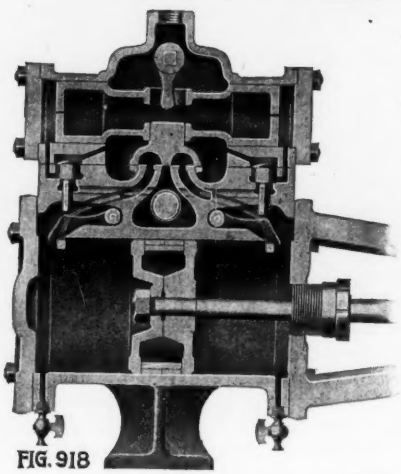


FIG. 918

SINGLE CYLINDER PUMP

John H. McGowan Co., Cincinnati, Ohio

The steam end of the boiler feed pump, shown in the illustration, avoids restricted steam passages, and the attendant wiredrawing of steam which is detrimental to successful operation. The reciprocating action is governed by the main steam piston, at the completion of each stroke through its contact with the tappet valve lever, which raises the tappet valve to release the steam from the corresponding end of the auxiliary piston. The resistance being thus removed, the steam contained in the piston end drives the auxiliary piston toward the point of release, carrying with it the slide valve which admits live steam to the main piston, thus starting it on its return stroke.

The slide valve is fitted to the auxiliary piston so as to permit of self adjustment to the port faces to compensate for wear and avoid leakage of steam.

The inside packed plunger type of water cylinder effects the same results in service as are obtained by the outside center-packed piston, with a large percentage less friction owing to the use of but one packing box to each plunger. It also has an advantage over the packed piston type in that the solid matter drawn into the pump at one stroke is not forced by the pressure due to discharge directly against the packing in the piston on the return stroke, which frequently results in severe wear of the packing and the cylinder itself. These pumps are therefore generally fitted with the inside-packed plunger, but if so desired the other types are used.

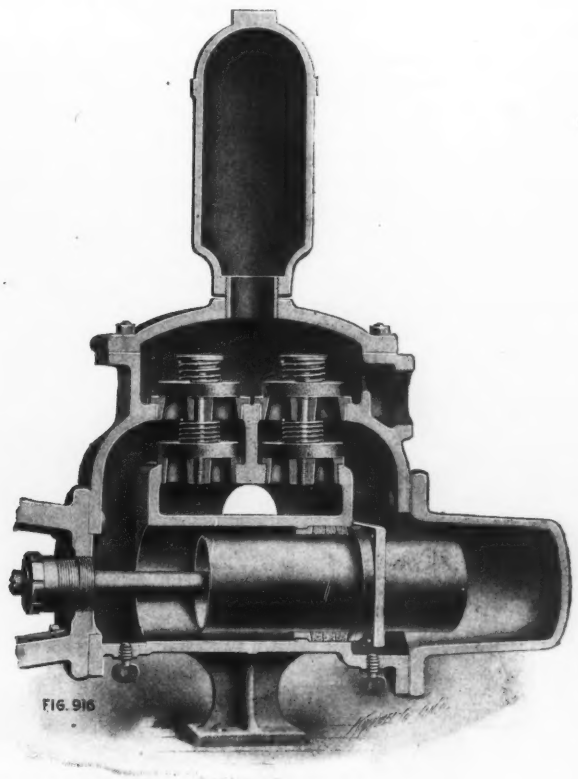


FIG. 916

M'GOWAN SIMPLEX STEAM PUMP

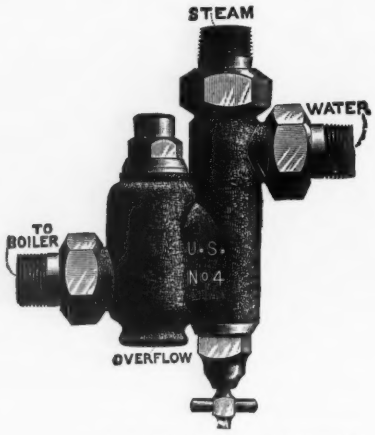
By this arrangement the pump can handle water at 212 deg. and do away with the possibilities of becoming steam bound. The boiler feed pump is free from air pockets, and affords as direct passage as possible from the suction to the discharge.

PROPER COVERING OF A BOILER and steam piping saves a large per cent of fuel.

ALLOW 1 SQ. IN. of area of pop safety valve for every 3 sq. ft. of area of grate.

INJECTORS

American Injector Co. of Detroit, Mich, manufacture the U. S. automatic injector, which is shown in the illustration, the characteristic features are the drip cock and the vertical lift overflow valve. By means of this drip cock, the injector may be drained when not in use, thus preventing freezing, and by leaving it open, the injector will start, even though the check valve leaks; and by means of this provision, it may be started with lower steam pressure when the drip cock is open.

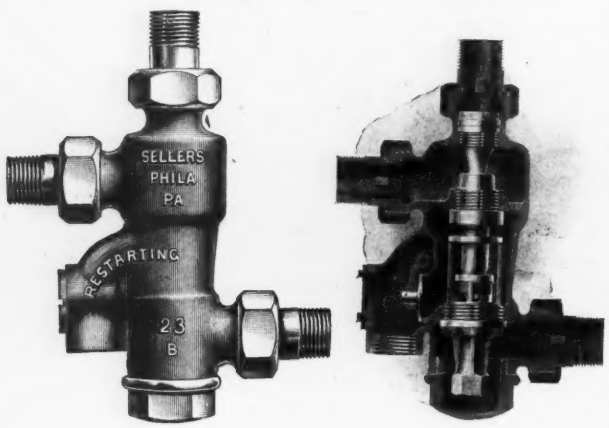


U. S. AUTOMATIC INJECTOR

Another feature is the disk valve on the delivery tube, which being cup shape, is forced to rise to its seat by the jet of water thrown against it from beneath.

The Garfield double jet injector, made by the Ohio Injector Co. of Wadsworth, Ohio, is designed especially for use on stationary boilers. It has no movable parts, requires no adjustment for varying steam pressures, and works well on high or low lift, hot or cold water. Its construction is simple and convenient for removing parts or valves for repairs.

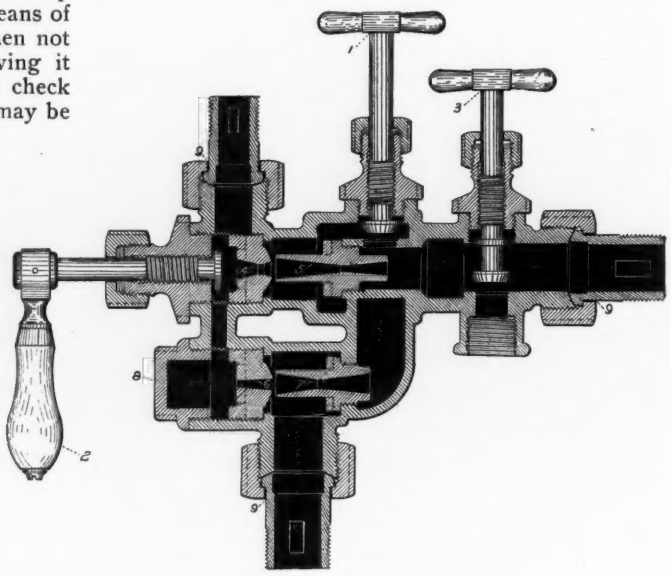
When it is necessary to clean any of the parts, they may be removed from the injector while the steam pressure is on the boiler, without breaking any pipe joints, or removing the machine from its connections.



THE SELLERS RESTARTING INJECTOR

The construction and operation of this injector will be understood from the illustration which is given herewith.

Jenkins Bros. of New York, N. Y., make the Sellers restarting injector which makes use of a light brass ring instead of a sliding bushing; also an external overflow valve is employed. The Sellers injector restarts instantly after a temporary interruption of the steam or water supply. It has a wide range of capacities, and lifts the water promptly with hot or cold pipes.



GARFIELD DOUBLE-JET INJECTOR

The areas of the body of the automatic injector made by the Lunkenheimer Co. of Cincinnati, Ohio, are ample, and the tubes are held squarely in place, but can be readily taken out for examination or repair. Steam entering through the pipe A, is condensed by the cold water which enters through J, which it forces through B and C, and to the delivery pipe to the boiler. The injector is of the vertical type, and the only moving part is the check valve E to the overflow.

The automatic injector which is made by the Penberthy Injector Co. of Detroit, Mich., differs from the positive type, in its simplicity of construction, and automatic qualities. It has but 3 working parts, the jets R, S and Y, the entire injector, including the body, consisting of 13 pieces.

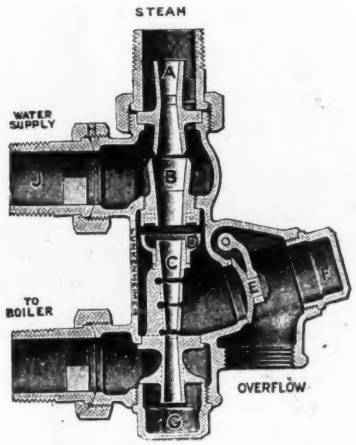
Steam enters at the jet R, passes through the jet S and out at P into the atmosphere. There is a strong vacuum at the junction of R and S, which raises the water to the injector. If the proportions of water and steam are right, a vacuum in the chamber at Y raises the valve T upward to its seat, when the water is directed through the jet Y to the boiler. The vacuum created in the chamber in which the jet Y is located, is sufficient to close the overflow valve.

When any condition occurs sufficient to break the current to boiler, the steam issues with a loud noise from the overflow, notifying the engineer. When conditions are restored, the valves S, P and T close automatically, and the injector restarts without any manipulation of valves by the engineer.

The Powell automatic injector, made by the Wm. Powell Co., Cincinnati, O., adapts itself to a wide range between the mimimum and extreme conditions,

long lifts and maintenance of its capacity through a wide variation of steam pressure.

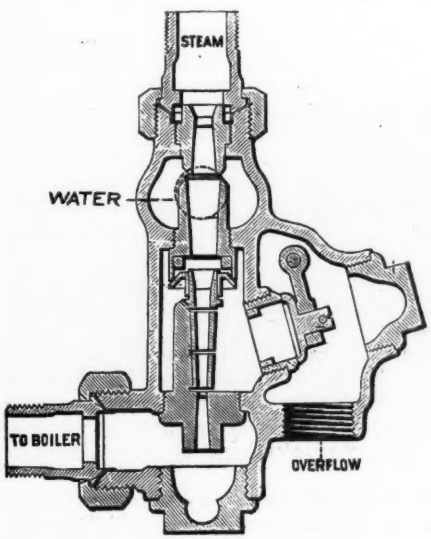
The design of the tapers and tubes, especially the delivery tube, is so constructed as to prevent the liming and scaling of the spill holes and other delicate parts. In the construction of the overflow valve, the seat is made independent of the main casting into which it is screwed. This permits the use of a superior alloy for the seat which insures a tight bearing, and allows the seat to be removed. A mechanical advantage is taken of the conditions caused by the action of



LUNKENHEIMER AUTOMATIC INJECTOR

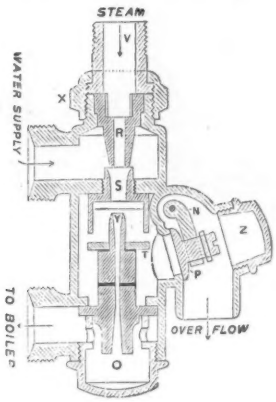
the elements in the injector, whereby this machine forms a vacuum which holds the valves closed, preventing spilling and breaking, so commonly experienced in using injectors for handling hot water supply.

The Leader injector, manufactured by the Randle Machinery Co. of Cincinnati, Ohio, is of the double-tube or positive type, simple in construction, and con-



POWELL AUTOMATIC INJECTOR

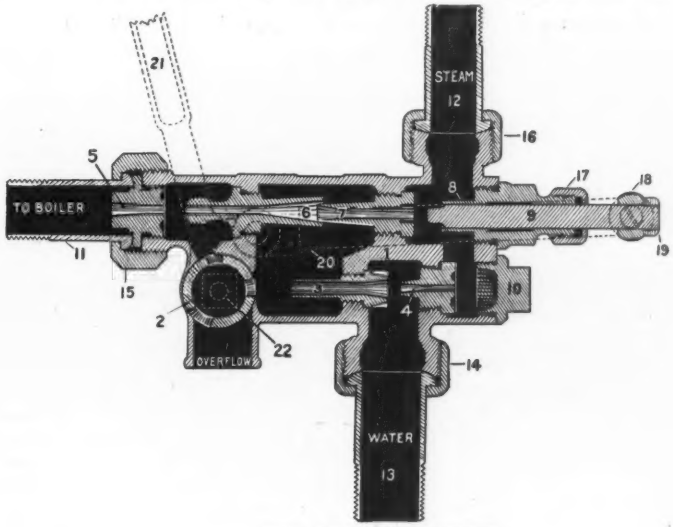
tains no moving parts or springs in its internal construction. It is used for feeding steam boilers from tanks or other water supply, and in so doing, heats the water to about 200 deg. As the water in the injector runs back to the well when the injector is stopped, there is no danger of freezing, and owing to its simplicity, it excels a feed pump in many ways, as a boiler feeder. With this device, water can be fed to the boiler through a closed heater, and it will also inject liquid boiler compound into a boiler for the prevention of boiler scale, by leaving the overflow slightly open and connecting a short pipe to run from the overflow into the compound. The feeding of boiler compound is done at the same time that the water is fed to the boiler, thus thoroughly mixing the compound and distributing it to all parts of the boiler. Boiler scale is very easily removed from this injector, by drilling



PENBERTHY AUTOMATIC INJECTOR

out the scale while the injector is on the boiler. The steam lifting tube is also cleaned out by removing plug No. 10.

In operation, steam enters through the pipe 12, and passing through the lifting tube 4, draws the cold feed water through the pipe 13 and forces it through the water lifting tube 3. Steam passes through the forcing tube 7, draws the water and forces it through the water forcing tube 6, by the momentum gained, the

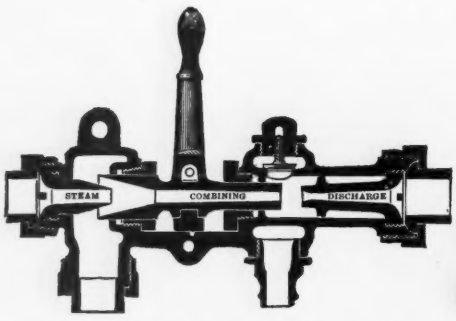


THE LEADER INJECTOR

water is driven through the end forcing tube 5, to the boiler.

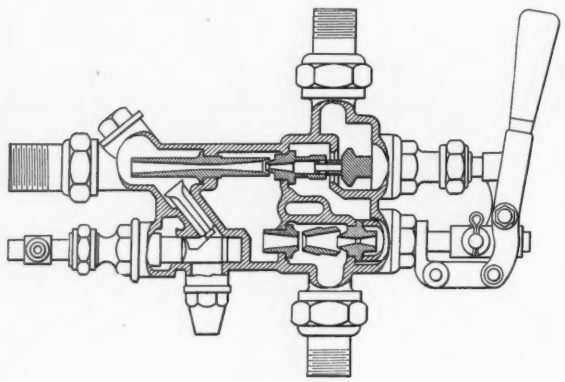
The Little Giant stationary injector, made by the Rue Mfg. Co. of Philadelphia, is fitted with a movable

combining tube operated by a lever which regulates the quantity of water for all conditions. When the water is to be raised, a lifter is placed in the water pipe with independent jet which permits the use of ordinary valves in place of special ones. The Little Giant Injector is simple in construction and contains no moving interior parts except the overflow horizontal check valve. All parts are easily accessible and the jets may be removed for cleaning, with very little inconvenience.



LITTLE GIANT STATIONARY INJECTOR

The universal double-tube injector, manufactured by Schutte & Koerting Co. of Philadelphia, is the combination of 2 jets, the lower jet is proportioned for extreme temperature and for quick and strong action, which includes maximum high suction. The discharge is into the upper jet, where the water receives the additional strong impulse to carry it into the boiler. The pressure and volume of the lower jet correspond to the steam pressure, and this is as it should be to answer the requirements of the upper or forcing jet. The varying volume insures the proper working at high steam pressure as well as at low, and increased pressure admits of increased high temperature.

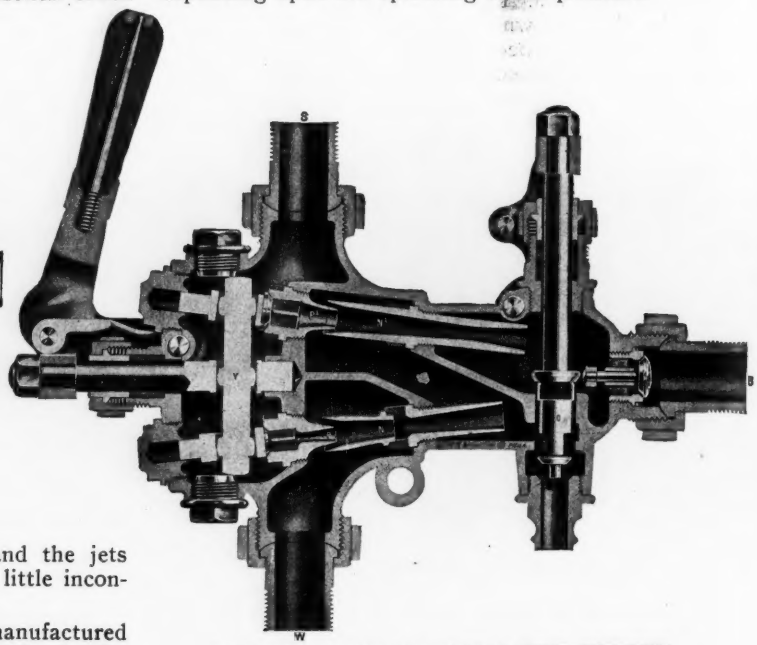


THE SHERWOOD INJECTOR

This injector will take water up to a temperature of 150 deg., and the limit in height of suction in all sizes is 20 ft.

All joints have single shoulders and the nozzles are fixed. There is no automatic starting check valve as the starting valve is connected to the hand lever and compelled to move with it.

Its range of pressures employed by the self-acting injector manufactured by the Wm. Sellers Co. of Philadelphia, extends from 15 to 300 lb. boiler pressure and the capacity can be reduced from 40 to 60 per cent, depending upon the operating steam pressure.



KOERTING UNIVERSAL DOUBLE-TUBE INJECTOR

The injector is simple in construction and is especially serviceable when the feed water is impregnated with lime, for during the operation of the injector the tubes are continually surrounded by a bath of cold water directly from the suction pipe, which tends to reduce the formation of scale.

The Sellers restarting injector requires no special valves, as the strong vacuum obtained when steam is admitted is sufficient to lift the water promptly. The tubes are firmly screwed into the injector and yet may be easily removed when it is necessary to remove any obstruction of the jet, which has passed through the pipes. The delivery tube projects beyond the bottom of the injector and ends in a heavy square or hexagon, so that an ordinary monkey wrench can be used to unscrew it.

The Sherwood injector, which is a product of the Sherwood Mfg. Co. of Buffalo, N. Y., is an apparatus comprising 2 sets of jets, 1 jet acting as an injector, lifting water and supplying it to the second jet, which forces it into the boiler. This arrangement produces truly automatic results, by working under varying pressures of steam. The injector requires no manipulation after being started, although the steam pressure should rise or fall.

Another advantage of the double tube type of injector, is its ability to work water of a higher temperature than a single tube type machine will do. It will also lift water a greater distance, and the construction of the apparatus is such, that it is better adapted to handle water heavily charged with mineral matter.

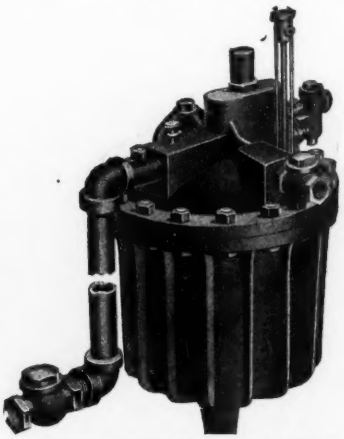
The operation of the Sherwood injector is shown by the sectional illustration.

RETURN TRAPS

CLASS "A" TRAP, IMPROVED RETURN BUCKET

Albany Steam Trap Co., Albany, N. Y.

Water of condensation from any steam system may be returned directly back to the boiler by means of this trap without the aid of a pump or steam loop. It will operate on systems working under varying pressures



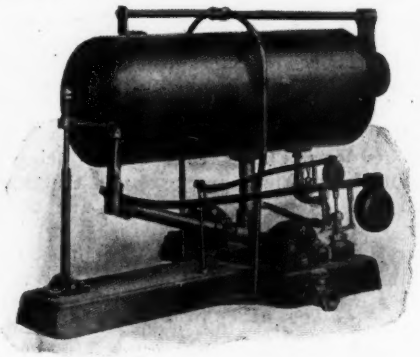
IMPROVED RETURN BUCKET TRAP

from 1 to 200 lb., returning the water at temperatures from 212 to 380 deg. Steam valves and devices actuating them are enclosed wholly within the trap itself, thus obviating the necessity of stuffing boxes and other like contrivances.

DETROIT RETURN TRAP

American Blower Co., Detroit, Mich.

This return trap is of the tilting tank type which operates upon a trunnion and is set perfectly level at any convenient point about 4 ft. above the water level of the boiler and as near to it as possible. The water is raised into the trap tank, which normally stands in a horizontal position. by the pressure carried on the sys-



DETROIT RETURN TRAP

tem. As the tank becomes filled with water, the tank tilts over, engaging with lever which automatically turns live steam from the dome of the boiler onto the surface of the water in the tank, thereby equalizing the pressure with that within the boiler. The water thereby is allowed to flow directly into the boiler by gravity. As the trap tank becomes empty, it is tilted back into its normal position by a weighted arm, and the process of refilling and dumping is repeated. When the steam pressure carried on the heating system is 10 to 15 lb. or more, it is only necessary to employ 1 return trap and receiver.

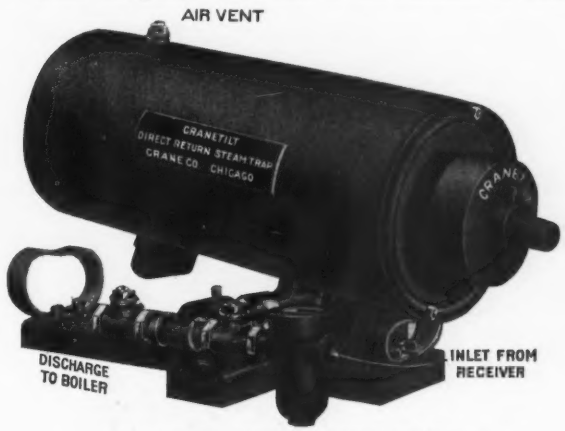
In manufacturing plants where exhaust steam is used for heating and drying, all the returns can be brought to a receiver and trap located where all the lines will be drained by gravity. The trap below is then employed as a water lift to a trap above the boiler.

CRANETILT DIRECT RETURN STEAM TRAP

Crane Co., Chicago, Ill.

This trap will automatically drain the water of condensation from any steam system and return it directly back into the boiler. When the trap is in the act of filling, the receiving drum is tilted at a slight angle toward the end carrying the balance weight, the discharge valve remaining closed while the trap is in this position. When the drum is properly filled it overbalances and tilts back to the level position, at the same time automatically operating the valves and lever mechanism by means of which live steam from the boiler is brought into the trap at the proper moment, and the water finds its level in the boiler by gravity. The trap lever also operates the relief valve, opening it to relieve the trap of pressure when ready to fill and closing it while discharging.

When the pressure or head is not sufficient to raise



CRANETILT DIRECT STEAM TRAP

the water to the return trap, which must always be located above the water line of the boilers, the dual system is used. This system consists of 2 return traps of the same size, the lower trap being situated so that the water will flow into it by gravity and acting as an intermediate lifting medium to the upper trap, which returns the water directly to the boilers.

CURTIS IMPROVED RETURN STEAM TRAP

Julian D'Este Co., Boston, Mass.

The water rising in the trap raises the float, which at the proper moment operates the valve, letting the full boiler pressure onto the surface of the water in the trap. A check valve on the inlet pipe prevents its return to the receiver and gravity causes it to find its level with the water in the boiler, with which it is connected by the outlet pipe through the boiler check valve.

Condensation falls by gravity into the receiver; it is forced thence into the trap. The water in the trap becomes connected top and bottom with the steam and water in the boiler and falls by gravity into it, the steam taking the place of the water and being in turn condensed by the incoming water at the next stroke. As there is no outlet to the air from the condensation surface there can be no waste of steam or water. The receiver being

located below the lowest drip pipe, the water of condensation falls into it by gravity and there must be enough pressure in the receiver to force the water up into the trap, which must be placed above the water line of the boiler.

When there is pressure on the water supply, this re-

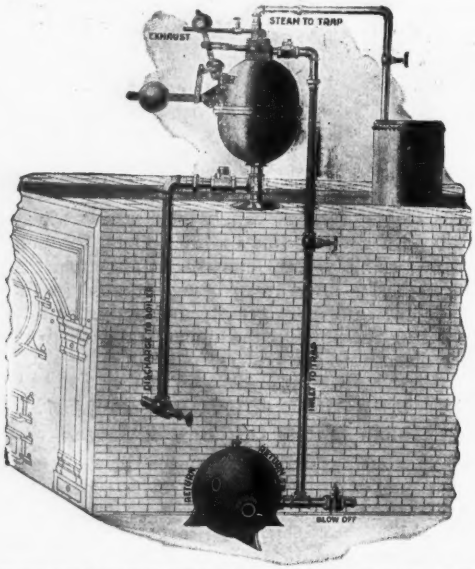
CURTIS IMPROVED RETURN STEAM TRAP

turn trap can be used to supply all the water in the boiler, thus doing the same work as pump and injectors.

KIELEY CHAMPION RETURN TRAP AND BOILER FEEDER

Kieley & Mueller, New York

Water of condensation from steam heating systems is automatically returned directly into the boilers by the use of this return steam trap. It should be placed in a situation where the bottom of the trap will be at least 3 ft. above the water line of the boiler, and works best where pressure is 5 lb. or over. In making connections



KIELEY CHAMPION RETURN TRAP AND BOILER FEEDER

high grade horizontal check valves must be used, as it is very essential that these be perfectly tight. The illustration shows the method of connecting this trap in the system.

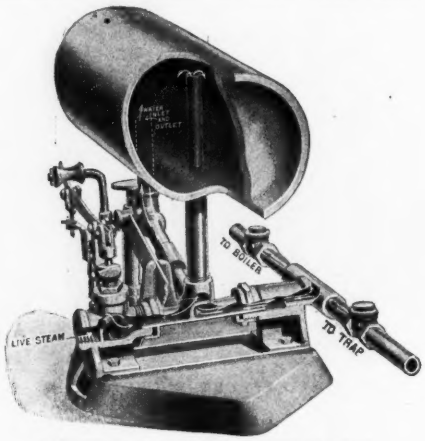
THE MOREHEAD TILTING RETURN STEAM TRAP AND BOILER FEED.

Morehead Mfg. Co., Detroit, Mich.

The prominent features of the Morehead traps are their simplicity of construction and the little or no attention required when in service.

The trap consists essentially of a steel tank, swung on a bass trunnion between 2 supports secured to a cast-iron bed plate. The supports consist of the valve connection on the 1 side and the water connection on the other, both of brass, and of such a shape as to form a secure and suitable rest for the trunnion.

In the return trap the admission and discharge of condensation takes place at the water end of the



MOREHEAD TILTING RETURN TRAP

trunnion while the valve end serves as an admission port for live steam. This valve serves as a steam admission port for the trap and has a removable disk, providing, at the proper time, a discharge for the contents of the trap.

The tank is counterbalanced by a cast-iron counterpoise weight on the end of a wrought iron lever. At the point of application of this lever to the tank an extension rod engages with a lever controlling the steam valve.

Leading from the valve casting of the trap is a weighted automatic relief valve, operated by a link connection from the steam valve lever.

Bolted to the bed plate, in a position just under the ends of the tank are 2 upright buffers which serve to limit the swing of, and provide resting points for the trap in its filling and discharge positions.

All valves and working parts are made of hard brass and rendered easily accessible by being located entirely outside, making the entire construction of the trap such that there is no possible avenue for the escape or waste of steam.

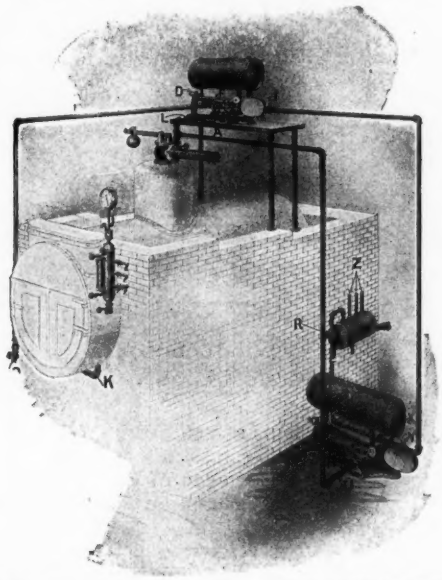
The trap tank, supported by the brass trunnion, is maintained normally in a horizontal position by means of a weighted lever. When sufficient water has entered the trap to overcome the action of the lever, the tank tilts downward, automatically opening the live steam valve, admitting steam at full boiler pressure above the condensation in the tank. The resulting equalization of pressure in the trap tank and boiler permits the natural flow of the water from the trap to the boiler.

The air valve provided for relieving the trap tank of all air pressure during the period of filling, is automatic in its operation and positive in action under all conditions. One of the prominent features of the trap construction is the arrangement of levers operating the valves. The movements of the levers are so graduated that it is impossible for the valves

to pound themeslves to pieces, or to pemit of the trap becoming air-bound.

Swing check valves located in the water supply pipe to and discharge pipe from the trap prevent, in the former case, the backing up of water into the supply pipe while the trap is discharging, and in the latter, the boiler pressure from interfering with the filling of the trap.

The adjustment of the weight on the main lever is such that, while allowing for the normal discharge of the contents of the tank, it prevents the discharge



MOREHEAD DOUBLE TRAP SYSTEM OF BOILER FEEDING

of that amount necessary for an effective water seal. The tilting movement with each discharge of the Morehead trap affords an absolute indication of the proper working of the trap.

THE HOLLY GRAVITY RETURN SYSTEM

Westinghouse, Church, Kerr & Co., New York City

The Holly gravity return system has been employed for a number of years to receive water of condensation from full pressure steam piping or apparatus irrespective of how far below the boiler water level it may occur and to return such condensation to the boiler at practically boiler temperature.

In modern power stations it is customary to select a location for the Holly receiver in some low central spot where the individual drip pipes or drip header may reach the receiver by gradient. If it is desired to carry the drip pipes in floor trenches, the receiver is placed in the floor trench also. The water of condensation, after reaching the receiver, is led upwards in a riser pipe by entrainment, to a secondary chamber, which is placed at an altitude of 30 or 40 ft. above the boiler water level.

From this upper chamber the water falls into the return pipe, connecting directly by independent opening to the boiler or boilers at some point well below the boiler water line through a horizontal swing check. A starting valve is placed at the end of the return line.

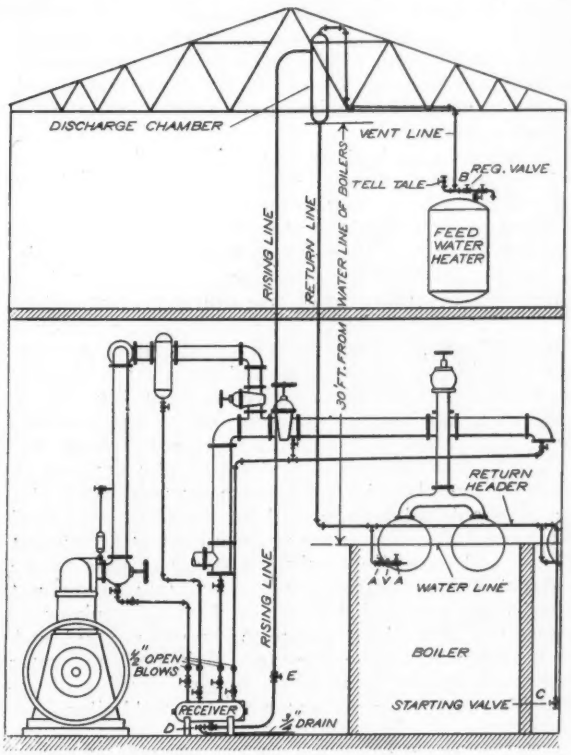
A small amount of vapor is allowed to escape by way of a vent line from the upper chamber for the purpose of insuring against an air-bound condition at this point, and to assist the upward entrainment. This slight escape of vapor is discharged into the feed water heater steam space.

To put the Holly system in operation as soon as steam is raised to about 20 lb. gauge pressure, all the valves in the drainage line, the valve in the riser line, and the boiler entry valves are opened wide, and the vent valve slightly opened. Circulation is established by opening the starting valve for a few seconds until all accumulated water is cleared from the system, when starting valve is closed and the system remains in operation.

After the system has been placed in operation it is found that the pressure loss in the upper or secondary chamber, due to initial and entrainment friction in the receiver and riser line, rarely amounts to 10 lb., as compared with the pressure in the boiler, so that the 30 or 40 ft. of altitude provided in vertical distance from the boiler water line to the upper chamber is ample to restore this loss and to insure the steady return to the boiler. The balancing point is usually about half way up and self-adjusting to such slight variations of pressure as may occur in the upper chamber.

During the years that this system has been upon the market, it has been tested out as to capacity under a great variety of conditions and can be depended upon to handle as much as 9,000 lb. of water per hour in a single riser pipe. Where larger quantities are to be taken care of, or where the physical layout is more scattered, it is customary to use a second unit.

The accompanying drawing illustrates in a diagrammatic way the application of the Holly gravity return system to power plant service and it has been applied with much success to various forms of high pressure



HOLLY GRAVITY RETURN SYSTEM

heating or high pressure drying apparatus, where in the nature of things substantially the full boiler pressure is sustained to the point of drip.

It is used for all pressures from 50 lb. upwards, the specific application in each instance being a matter of careful engineering study and determination.

FEED WATER CONTROL

Irregular feeding of water to boilers is productive of more serious trouble and waste than many suppose. The injection of a large quantity of water at one time has a tendency to stop circulation and concentrate the flow of water in the lower section of the boiler, causing unequal expansion of the parts, and severe and often destructive strains on the joints. A common defect in cylindrical boilers, is what is known as seam cracks, which are small crevices appearing in the plates or at the rivet lines. These cracks are only the result of expansion and contraction strains, and are greatly augmented if the parts in the shell are overheated.

The waste of fuel is also an important result of irregular feeding. Retarded circulation over the heating surfaces, reduces their efficiency in a remarkable degree, and causes heat to escape to the chimney, that should be absorbed by the water in the boiler. Experience has proved that water in circulation will absorb heat from the surfaces of the boiler far more rapidly, than water that is still or moving slowly. In some cases, by the employment of feed water regulators, as much as 15 per cent gain in efficiency has been obtained.

Contributing to this result, is the increased steadiness of the generation of steam, which is permitted by the use of a water regulator. When a boiler is steaming rapidly, the steam rises from the surface of the water in a turbulent and violent manner, carrying water up with it in considerable masses. Steam carried over from the boiler to the engine cylinders will cause water hammer, and frequently ruptures the steam piping and fittings, racking the engine, and frequently destroys an engine beyond repair. The sudden fall of 5 or 10 lb. in pressure, caused by the sudden inflow of cold feed water, may cause the boiler to prime, and the steam to carry water over to the engine cylinder.

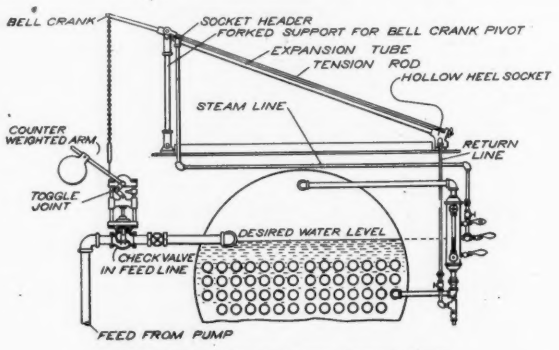
More boiler explosions are attributed to low water than any other one cause; for, as soon as a surface subject to the direct action of hot gases is uncovered by water, its temperature may rise nearly to that of the fire itself. Iron and steel lose their tensile strength below 1000 deg. F., and it is not surprising, that under these conditions, bulges, bags, and pockets are formed; or that the plates or tubes give way entirely. Even, if this does not happen, the abnormal or uneven heating of the parts, shell and tubes, causes stresses that are apt to start the seams and tube ends; or to overstrain the metal. Plenty of steam space in the boiler is a favorable advantage, and by the use of the feed water regulator, this space may be kept at a constant volume and thus allow only dry steam to pass to the engine. The apparatus used to maintain a constant water level in the boiler is the feed water regulator, in connection with which, pump governors are employed. As a safeguard to the operator, high and low water alarms are frequently installed, to give warning of approaching danger in the water level in the boiler.

THE COPES BOILER FEED REGULATOR

American Boiler Economy Co., Philadelphia, Pa.

The primary regulating device is a straight composition tube located above the water line at any convenient place in the boiler room, and so connected that when the water level is above the desired point the tube will be full of water; and when it is below the desired point, the tube will be partly or wholly filled with steam. Water confined in the tube, exposed to the air suction, cools to a lower temperature, while the steam-filled tube remains hot, because it is constantly supplied with heat by the condensation of the steam. The tube will be longer when the water is below the desired level, and shorter when it is above; and since expansion of the solid metal is practically irresistible, this presents a suitable device for regulating the admission of water to the boiler.

The connections to the expansion tube consist of 2 small pipes, one leading from the lower end of the expansion tube to the water connection of the water column,



THE COPES BOILER-FEED REGULATOR

and the other from the upper end of the expansion tube to that point in the water column at which it is desired to carry the water level.

The expansion tube is screwed at one end into a socket base tapped with 3 holes, one upon each side for taking off the water column connection in the direction that may be most convenient, and one at the rear for a blowoff cock. The upper end of the expansion tube is screwed into a brass cap, similarly tapped for the steam connection, and bearing at its forward end a short thrust bar, which, through a bell crank lever and the pilot valve of the bell crank, operates the controlling inlet valve to the boiler.

When steam is admitted to the expansion tube it will raise the end of the bell crank lever; this, through a chain and turnbuckle, raises the long arm of the weighted bell crank lever below, the short arm, which is a part of the toggle motion, actuating a spindle in the top of the check valve in the boiler feed line. When this weighted lever is raised, the valve is free to admit water to the boiler, and when the expansion tube cools, the lever will be allowed to fall, and thus shut off the supply of water.

BERRY FEED-WATER REGULATOR

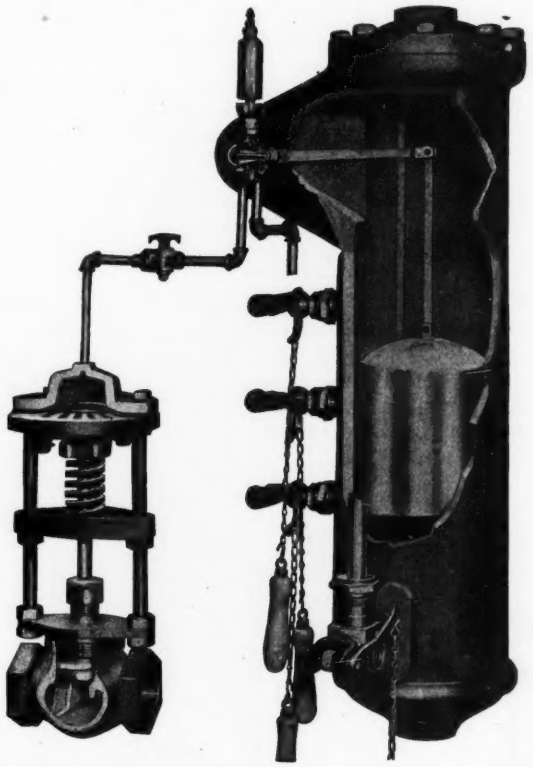
Berry Engineering Co., Chester, Pa.

It will be seen from the illustration that this feed controlling apparatus is placed in an iron water column and operated by a float connected to the stem of a rotary pilot valve in such a way as to have a leverage of 20 to 1, so that 12 in. of vertical float movement rotates the valve ¼ turn. This rotary valve fits in a conical seat in which are 4 ports that are connected through corresponding passages in the plug to external threaded openings into which pipes are screwed; one of these openings leads to the alarm whistle and another to the exhaust.

When this apparatus is used in connection with a steam pump the usual diaphragm arrangement is employed and connection made by one of the pipes to the

diaphragm chamber, so that when the float rises or falls, the steam will be admitted to or exhausted from the diaphragm, thus causing the feed valve to open or close, as the case may require.

The special features of this machine are, the patented arrangement by which the pilot valve and its seat, to-



BERRY FEED-WATER REGULATOR

gether with the small parts connecting it, can be removed and replaced while steam is on the column; and the non-collapsible float.

THE TURNER SAFETY COMBINED HIGH AND LOW WATER ALARM COLUMN

Binghamton Machine Tool Works, Binghamton, N. Y.

It will be seen from the sectional illustration here given, that the Turner high and low water alarm column consists of a chamber connected above and below the water line of the boiler, within which a seamless copper float operates. The float surrounds a rod, and in its extreme positions operates steam valves which admit steam to the whistle, notifying the operator of the danger limits in the water supply.

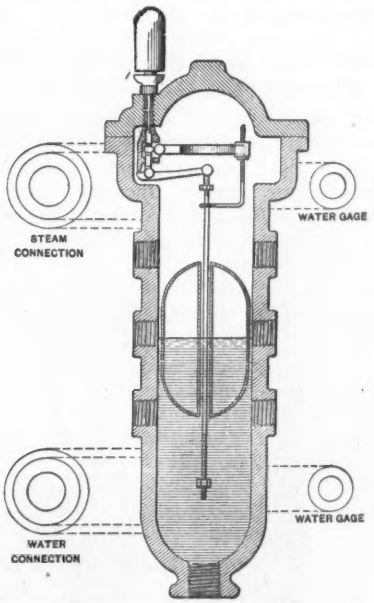
All the internal mechanism of this water column is attached to the head, which can be removed at any time without breaking connections to the boiler.

VIGILANT FEED WATER REGULATOR

Chaplin, Fulton Mfg. Co., Pittsburg, Pa.

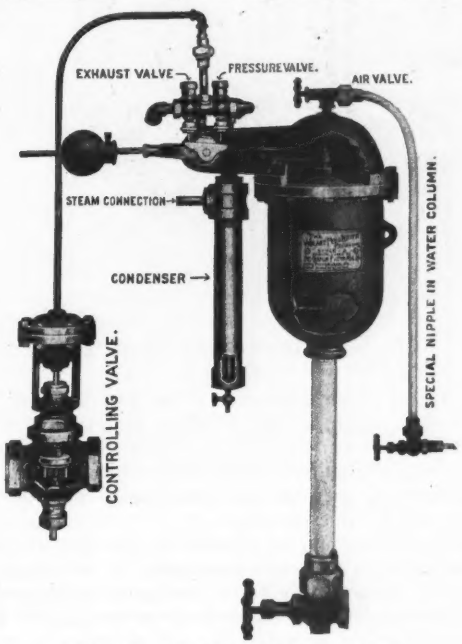
The cut which is here given represents style No. 2 of the regulator which is manufactured by this company is of a balanced float type and is provided with a valve casing containing 2 separate valves, which are called respectively pressure and exhaust valves. In operation, when the displacement body is at its lowest point and the water about to flow into the boiler, the weighted lever will rise and the rocker arm come in contact with the stem of the exhaust valve, opening it and releasing the pressure from the diaphragm of the controlling valve. The valve will then open, permitting the water to flow into the boiler.

On the return operation, the weighted lever will fall, due to the rise of the displacement body, when the ex-



TURNER SAFETY COMBINED HIGH AND LOW WATER ALARM COLUMN

haust valve will be closed by the spring and the rocker arm will come in contact with the stem of the pressure valve opening it, and permitting the pressure to be con-



VIGILANT FEED-WATER REGULATOR

veyed to the diaphragm of the controlling valve, thus closing it and shutting off the flow of water into the boiler.

A condenser is also shown in the cut of the regulator,

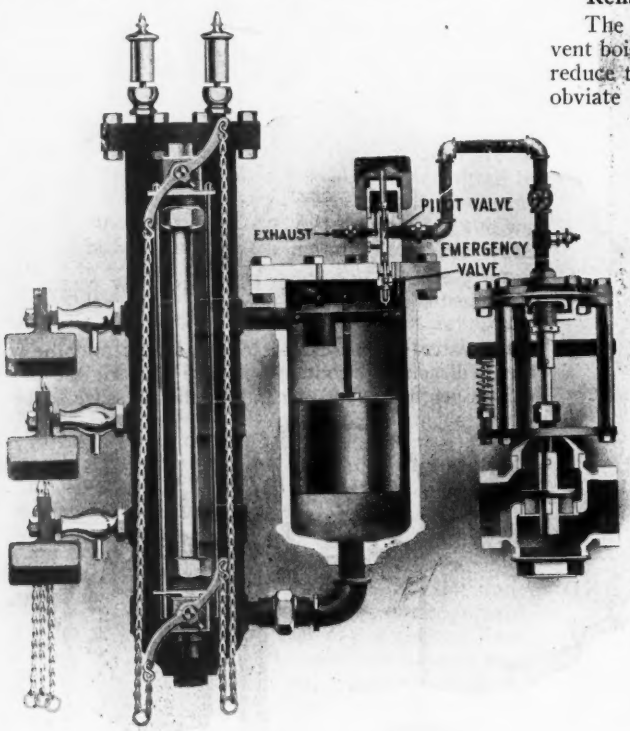
the purpose of which is to furnish a supply of pure water for use through the valves. The steam connection is made to the condenser at the point marked in the cut and it is the condensation in this chamber of the live steam from the connection to the boiler which is carried through the pressure and exhaust valves in their operation and prevents their going out.

KITTS FEED WATER REGULATOR

Kitts Mfg. Co., Oswego, N. Y.

Kitts feed water regulator is designed to maintain a constant water level in steam boilers at the point of maximum, heating surface and maximum steam space, thus securing the greatest possible efficiency from the coal, preventing strain from sudden contraction and expansion, and obviating the danger of explosions by low, or flooding by high water.

This regulator is composed of a high and low safety water column, a feeder column, and a feed valve.



KITTS FEED-WATER REGULATOR

The safety water column is fitted with 2 whistles of different tone which, in case of either high or low water, are operated by separate gravity weights attached to compound levers. Gravity weights are used instead of hollow ball floats, as they are considered much more durable, being practically indestructible.

The feeder column is attached to the alarm column at the same water level, and is operated by a solid gravity weight and counter-weight, producing a positive action which responds to the slightest variation of the water level.

A removable pilot valve is attached to the feeder column and responds to its slightest movement, opening or closing the feed valve just sufficient to feed water to the boilers for a constant water level. Should the water move above the level the gravity weight in the feeder column rises, opening the pilot valve and allowing the steam to act on the diaphragm of the feed valve, and close it. Should the water drop below the level the action is reversed, and just the necessary amount of water is supplied to the boiler.

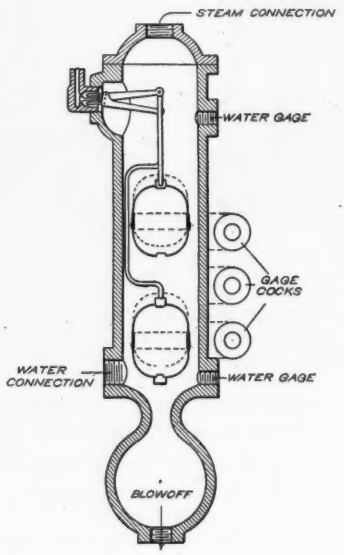
A most desirable feature of the pilot valve is that it can be easily detached for inspection while under full boiler pressure. The feeder column is provided with an emergency valve, which immediately closes when the pilot valve is removed.

The feed water valve is regulated by the feeder column and its control is absolute and easy. The adjustment spring placed on the outside is to open the water valve when the steam pressure is shut off by the action of the pilot valve. The threaded sleeve under the diaphragm controls the valve disk so that a constant flow of water can be obtained if desired. The valve seat and disk can be removed at any time by unscrewing the cap of the valve.

COMBINED HIGH AND LOW WATER ALARM

Reliance Gauge Column Co., Cleveland, Ohio

The purpose of these appliances is not only to prevent boiler explosions but to prolong the life of the boiler, reduce the cost of maintenance, lessen the waste of fuel, obviate stoppages and protect life and property, all of which is accomplished by causing the water to be carried steadily at the proper level. These columns have a sediment chamber, providing protection against the danger arising from sediment. The valves are also placed high above the high water mark and are so constructed as not to become stopped up.



COMBINED HIGH AND LOW WATER ALARM

The low water part of the combined high and low water alarm consists of a bell crank lever connecting the valve with the float, which, by reason of its buoyancy, presses upward, holding the valve closed so long as the water line is above the center of the lower gauge cock, but which by reason of its weight opens the valve, thus blowing the whistle whenever the water line goes below that point. The high water alarm is simply the low water alarm reversed, the bell crank lever being turned over so that the float hangs upon it as a weight until the water gets sufficiently high to lift it and blow the whistle.

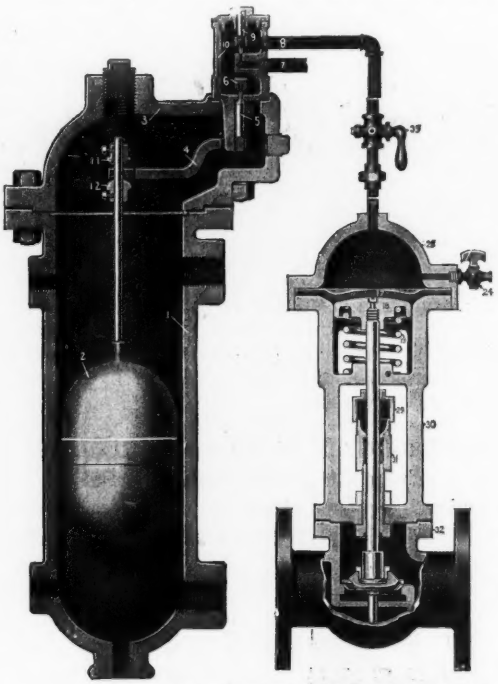
The construction and method of connecting the water column to the boiler will be clearly understood from the accompanying illustration. The low water alarm in these columns can be instantly tested at any time by anyone interested, by opening the valve in the column blowoff pipe and letting the water out of the column, the effect upon the column being exactly the same as if the water were actually lower in the boiler. The high water alarm can be tested by closing the valve in the steam pipe.

THE LIBERTY FEED-WATER REGULATOR

Liberty Mfg. Co., Pittsburg, Pa.

The Liberty feed-water regulator is designed to maintain automatically a constant water level in the boiler by controlling the inlet valve.

Assuming that the water in the boiler is at the lower

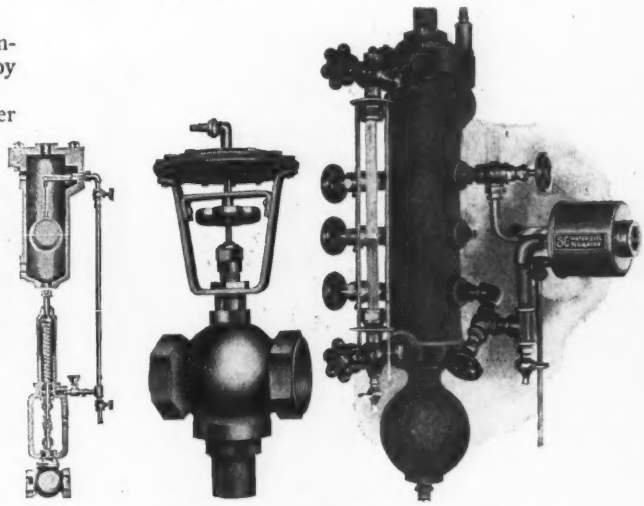


THE LIBERTY FEED-WATER REGULATOR

level, the valve on the end of the stem 5 is open, and the valve on the end of the stem 9 is closed; the steam is then entering the pilot valve chamber and passing through the pipe 8, into the chamber on top of the controlling valve, the pressure forcing this valve to its seat. As the water evaporates, the water level in the boiler and column lowers, and the weight of the float is gradually transferred to the lever. This continues until the weight of the float overcomes steam pressure, holding the valve 9 on its seat, which is then opened, and the weight of the float seats the admission valve, and the steam that is contained in the pipe 8 passes through the exhaust valve and through the pipe 7 to the atmosphere. This relieves the pressure on top of the diaphragm and permits the controlling valve to open and admit water to the boiler.

This continues until the water level has been raised about ½ in. and as the water level rises in the boiler and column, the float has a tendency to rise likewise; but the steam pressure on the admission valve tends to keep that valve closed, consequently prevents the float from rising until the weight due to the increased displacement of the float overcomes the pressure at the admission valve; and as it opens, the exhaust valve 9 closes, causing the steam to enter the controlling valve pipe and forcing this valve to its seat.

These regulators are very substantially built, particular attention being given to the controlling valve, and it will be noticed that all parts are made much heavier than usual. The top of the diaphragm chamber extends down over the diaphragm so as to prevent the diaphragm from blowing out. The pilot valve is made entirely of special grade of bronze, with removable seats. The floats used in these regulators are all tested to 400 lb. per sq. in. before they are sent out from the factory.



MURRAY BOILER-FEED REGULATOR
THE "S-C" REGULATOR

MURRAY BOILER FEED REGULATOR

Murray Automatic Boiler Feed Co., Detroit, Mich.

The device here illustrated automatically holds the water in the boiler at the desired level, which is a practical necessity in order to secure the highest efficiency of the boiler. In operation whenever the water in the boiler falls below its normal level the float in the column will open the needle valve and admit steam through the ¼-in. pipe into the lower end of the cylinder, thereby forcing up the piston against the tension of the spring and through the piston rod, opening the regulating valve. This will admit water through the feed pipe into the boiler until the normal level is restored. As soon as this occurs, the needle valve will again close by the rising of the float, shutting off the steam from the ¼-in. pipe and allowing the spring to compress the piston, closing the regulating or feed valve.

THE "S-C" REGULATOR

The "S-C" Regulator Co., Fostoria, O.

The "S-C" regulator consists of a generator and a diaphragm controlling the balanced valve in the feed line, or where only one boiler is used, the valve is placed in the steam line to pump and serves as a pump governor and regulator at once.

It is designed to work on the generation and condensation of steam in the generator or independent boiler, which is a thin copper shell, containing the rounded end of, and fired by, a seamless brass tube bent in the form of the letter U and placed with the parallel parts horizontal, one above the other, and on a level where the water in the boiler is to be carried.

One end of this tube is connected direct to the boiler

through the upper, and the other end through the lower, trycock opening in the water column. This gives an open passage for steam and water the same as the water glass. The generator is then connected by brass tubing to the diaphragm and both are filled with water to a point in the generator just covering the loop or tube.

When the water level in the boiler is above this point the loop is filled with water. As the water level in the boiler drops, the water in these connections to the column also drops until the point is reached where the water runs out of the loop, thus admitting steam into the loop and boiling the water in contact with it in the generator. The independent pressure thus created acts, through the

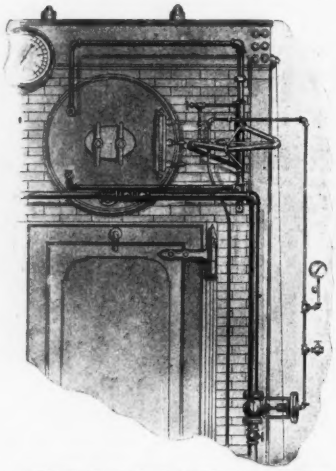


FIG. 1. SQUIRES REGULATOR ATTACHED TO BOILER

connecting tubing, on the diaphragm, opening the feed valve and allowing the pump to feed the boiler until the water level rises, displacing the steam in the loop, when the thin copper shell of the generator condenses the steam and the spring in the reverse side of the valve closes it, retarding the action of the pump and also forcing the water from the diaphragm back into the generator ready to work on the slightest admission of steam to the loop, caused by the water level in the boiler being again lowered.

THE SQUIRES BOILER FEED WATER REGULATOR

The Strong, Carlisle & Hammond Co., Cleveland, Ohio

The object of this device shown attached to a boiler in Fig. 1 is to maintain a constant water level in the boiler. This is accomplished by a feed controller, known as a "harp," attached to the boiler at the normal water level, which, by expansion and contraction due to varying temperature, actuates a regulating valve in the feed water line. This feed-water regulator should never be used except in connection with a pump governor, unless the boilers are fed with city water pressure.

The pilot valve shown in Fig. 2, which is the vital part of this apparatus, is a 3-ported valve with a single seat. If the water level in the boiler is such that the valve is closed, steam from the harp column flows in and meets the resistance plug, which is turned 1/64 in. smaller in diameter than the cylinder. Some of the steam leaks past the plug and enters the pipe leading to the feed valve, and by maintaining a pressure upon this diaphragm, prevents water from entering the boiler. Then as the water level falls, the harp heats up and expands, and the valve is pulled off its seat. Steam flows out of the pressure pipe leading to the feed valve and discharges through the exhaust connection. Pressure is immediately relieved on the feed valve diaphragm, the result being to force the water more rapidly into the boiler.

When a certain level is reached, the harp again contracts and the pilot valve is closed by the spring. In order to understand the regulator better the action has been described as intermittent; in actual service the feed is constant, the feed valve remaining open just enough to supply the boiler, and there is always a slight exhaust when the regulator is in service. The turnbuckle makes the valve stem adjustable for regulating when starting up.

The feed valve which is illustrated in section in Fig. 3 is of the single-seat globe type and is operated by water pressure acting on a diaphragm. When the water is high in the boiler the pressure from the pilot valve acts

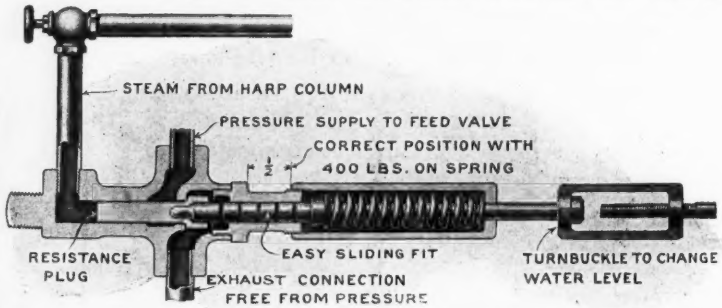


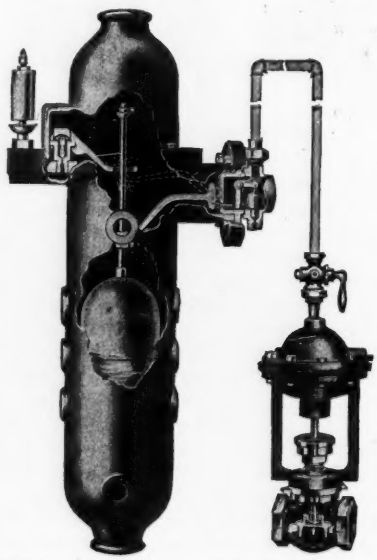
FIG. 2. PILOT VALVE, SQUIRES REGULATOR

on this diaphragm and closes the valve. When the pressure is relieved, the valve is opened again by the spring. The diaphragm is made of sufficient diameter to work with a low pressure, and at the same time have ample capacity to handle the valve.

WILLIAMS SAFETY WATER REGULATOR

The Williams Gauge Co., Pittsburg, Pa.

The Williams regulator embodies all the features of the high and low water alarm and feed water regulating



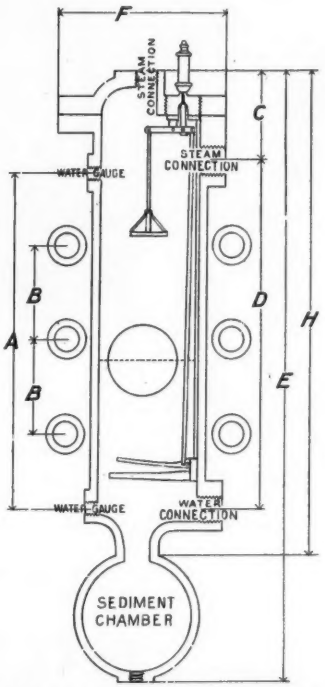
WILLIAMS SAFETY WATER REGULATOR

device, combined in a compact and convenient form. The appliance, when being installed on boilers, will take the piping connections originally used for a water column,

thus eliminating any additional piping in equipping boilers with the regulator.

By referring to the illustration it will be seen that the appliance consists of a column and a controlling valve. This controlling valve is placed in the feed line to each individual boiler at the most convenient point and performs the same functions as the ordinary hand valve, it merely being so adapted that it may be operated by the controlling device located in the larger projection from the column, far removed from scale deposits.

When the water in the boiler is at the desired level steam is entering through the inlet valve, which is held open by means of the float and lever, passing thence from the steam chest through the pressure pipe to the diaphragm in the top of the controlling valve, causing this valve to close. When the water in the boiler falls



WRIGHT IMPROVED SAFETY ALARM WATER COLUMN

from evaporation or other cause, the float and lever in coming down close the inlet valve, which opens the exhaust valve, relieving the pressure from the top of the diaphragm, and thus permitting the controlling valve to open and admit water to the boiler.

The water level under ordinary conditions may be held within 3/8 in. variation; the machine being of the intermittent type, and causing small quantities of water to be fed uniformly to the boiler, prohibits all danger of wire drawing through the controlling valve and thus overcomes the objectionable feature of a continuous feed. It will be noted that the same float which operates the regulating device also controls the high and low alarm whistle valve.

THE WRIGHT IMPROVED SAFETY ALARM WATER COLUMN

Wright Manufacturing Co., Detroit, Mich.

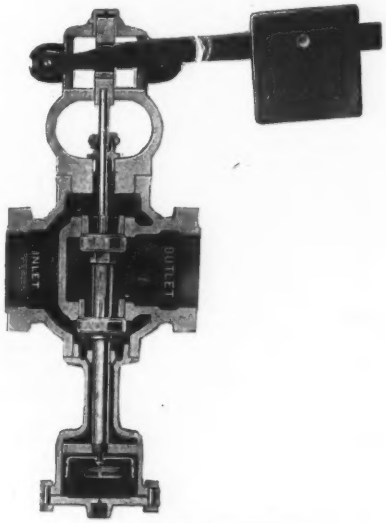
One vertical valve and one seamless round float are the special features involved in the Wright high and low and low water only alarm columns. All the working parts are attached to the cap, permitting easy access for inspection. Gauge cocks in either side facilitate right or left hand connections.

The float consists of a ball, which has no connection to any other part of the appliance. At the water limits this float comes in contact with levers, which operate the steam valve and the alarm whistle. The provision of a sediment chamber keeps the boiler scale from the interior of the column, thus preventing the float from becoming clogged.

FULTON PUMP GOVERNOR

Chaplin, Fulton Mfg. Co., Pittsburg, Pa.

The Fulton pump governor which is here illustrated has no complex or delicate parts to wear out, is easily understood and operated and is used to regulate the speed of the pump, according to the requirements of the boilers. It maintains a constant difference between the pressure in the feed pipe and the pressure in the boilers, that is, if the excess of pressure in the feed line



FULTON PUMP GOVERNOR

is fixed at 10 lb., this pressure will always remain constant, no matter how much the boiler pressure may fluctuate.

As the boiler pressure is carried on one side of the piston of the pump governor and the pump pressure on the other, it is only this small difference of pressure that has to be balanced by the weight and lever of the governor.

The governor which is here illustrated is one in which the pump pressure is communicated to a metallic piston, which is directly connected to the steam inlet valve to the pump. This company also manufactures a governor in which the pressure is communicated to a diaphragm, so located that it will not burn out.

THE CARR PUMP GOVERNOR

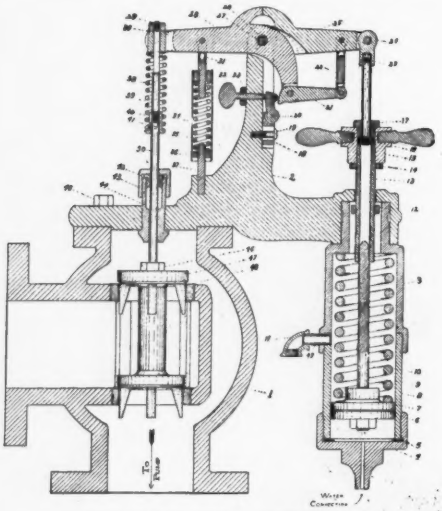
E. M. Carr Pump Governor Co., Newcastle, Ind.

The object of this governor is not only to maintain a uniform water pressure on the mains, but also to prevent the pump from racing should a greater quantity of water be consumed than the pump is capable of delivering.

The speed controller plays no part in the operation of the governor until the pump reaches a speed to

which it is set, then it comes in for its part of the work and prevents any further increase of speed regardless of the drop in the water pressure, and the lower the pressure falls the closer the valve will be brought to its seat, thus throttling the steam and maintaining a uniform speed, which insures protection to the pump should the largest main or discharge pipe of the system burst, or a greater quantity of water be consumed than the pump was capable of delivering.

The cylinder of this governor is so located that it is perpendicular and parallel to the valve body and not exposed to the heat and will not lime up or streaks of lime can not form and prevent the free action of the piston making a very sensitive governor, and one that is especially adapted for boiler feed pumps. The regulating hand wheel is so located that it always remains cool and the governor can be regulated to any desired water pressure in a few seconds time without injure to the hands or the use of a wrench.



THE CARR PUMP GOVERNOR

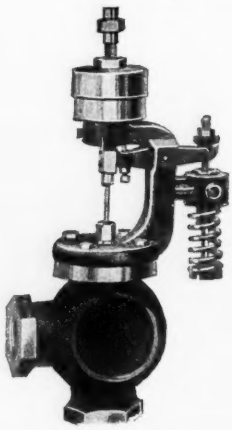
The sectional view of the Carr pump governor shows the renewable valve and seat that are fitted to all of the Carr pump governors. It will be seen that the seats are so bridged together that no unequal expansion can take place between the valve and seats, insuring a tight valve under all temperatures of steam.

The Carr pump pressure regulators are made in all sizes from ½-in. to 1½-in., and are not classed as pump governors, although they are provided with a speed limit device which will prevent racing so long as the consumption is not such as to cause too great a drop in the water pressure. This style is especially suitable for boiler feed pumps feeding boilers provided with automatic feed water regulators, as no throttling of the pump is necessary as the speed limit can be set to any desired speed, which will prevent all danger of racing when the feed valve opens.

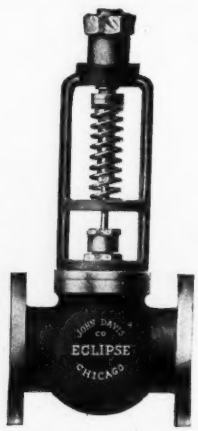
ECLIPSE PUMP REGULATOR

The John Davis Co., Chicago, Ill.

The regulator which is shown in the illustration is adjusted by a spring which operates upon a water piston, the position of which is controlled by the water pressure in the discharge line from the pump; the connection being made through a small pipe attached to the top of the regulator. The piston is directly connected to the steam inlet valve by means of a stem, and will maintain a constant pressure in the discharge line of the pump. These regulators are made in either globe or angle pattern.



THE CARR PUMP PRESSURE REGULATOR



ECLIPSE PUMP REGULATOR

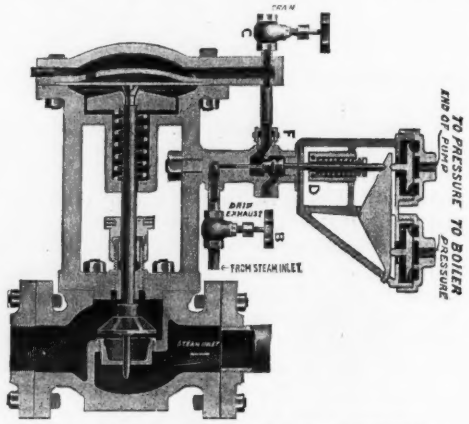
THE SQUIRES EXCESS PUMP GOVERNOR

The Strong, Carlisle & Hammond Co., Cleveland, O.

In order that a constant pressure be maintained in a boiler, it is necessary that the pump be given just the necessary amount of lead in pressure to overcome the friction, head and a few pounds lead in the boiler.

By the use of this pump governor the pump pressure is regulated by its own action combined with that of the boiler pressure through 2 small diaphragms pressing upon the ends of the equalizing bar which controls the movement of the pilot valve. The pilot valve admits or relieves the pressure upon the large diaphragm operating the main valve.

The pump pressure and the boiler pressure are applied at the ends of the equalizing bar, and the excess of pressure on the pump pressure end of the bar is resisted by a spring which is adjustable by turning the adjusting nut. In use, the equalizing bar is balanced between the spring and boiler pressure, acting one way and the pump pressure resisting this action. It is affected by the slightest change in either the pump or boiler pressure, and as long as the pump pressure is at a constant excess over the boiler pressure, the equalizing bar will exert a constant strain upon the spring



THE SQUIRES EXCESS PUMP GOVERNOR

regardless of how high or low a boiler pressure is carried. When the excess is exactly at the determined point, the pilot valve and main feed valve will be closed.

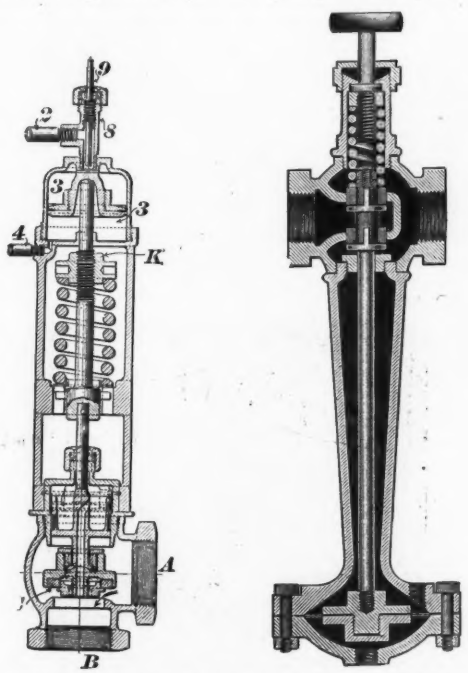
Additional excess pressure increases the pressure of the equalizing bar on the pilot valve stem which keeps the pilot, and consequently the feed valve shut until the excess falls below the desired point. When the pump pressure gets below the determined excess, the equalizing bar exerts less pressure on the pilot valve, allowing it and the governor valve to open. The feed will then open to full pipe area, if necessary, to maintain the excess.

THE FOSTER PISTON ACTUATED PUMP GOVERNOR

Foster Engineering Co., Newark, N. J.

This device is designed to control a steam pump solely by the discharge pressure from the pump, and is made throughout of steam metal composition, in sizes up to 2 in., above which iron bodies with composition seats and trimmings are used.

The steam inlet is at A, and the outlet leading to the pump at B. Connection is made by the pipe 2, between the governor and the pump discharge or pressure tank. The fitting 8, connected to the top of the water cylinder, is provided with a limit screw 9, which is used to prevent excessive movement of the piston and violent vibration of the working parts.



FOSTER PISTON-ACTUATED PUMP GOVERNOR
D'ESTE FEED-WATER REGULATOR

The water pressure acting on the piston within the cylinder 3, tends to close the steam valve against the power of the spring, the pressure of which is regulated by the adjusting nut K.

THE BOILER FEED PUMP REGULATOR

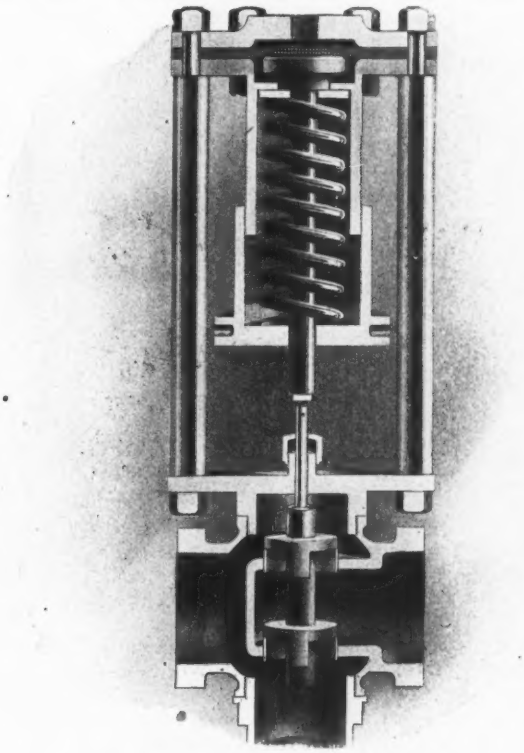
Julian d'Este Co., Boston

This regulator consists of a balanced valve, diaphragm chamber containing diaphragm, and top spring with a device for compressing same. The water from the feed line is connected under the bottom of the diaphragm, and the steam pressure from the boiler on the top of the diaphragm. It will be readily seen that the more the top spring is depressed, the greater difference will be shown to exist between the boiler pressure and feed-water pressure; this can be so regulated that any desired pressure from a few pounds up may be maintained.

KITTS PUMP PRESSURE REGULATOR

Kitts Mfg. Co., Oswego, N. Y.

Kitts pump pressure regulator is automatic in its action and maintains an unvarying pressure which prevents pump racing and straining and bursting of pipes. When no water is being used, the pump is at rest, but as soon as the valve on the water line is opened the pump starts slowly, gaining in speed until the uniform pressure is reached.



KITTS PUMP PRESSURE REGULATOR

It is made of heavy bronze, with a special diaphragm, and wide range tension spring, designed for any pressure up to 300 lb.

The water pressure in the discharge pipe of the pump is transmitted to the diaphragm at the top of the regulator and thus by means of a rod operates the steam inlet valve to the pump.

To regulate the pump to any desired pressure, adjust the spring to open or close the valve by turning the cap on the chamber containing the spring.

WATSON STEAM PUMP GOVERNOR

Watson & McDaniel Co., Philadelphia, Pa.

The pump governor is designed to maintain the same water pressure in the boiler, automatically increasing or decreasing the speed of the pump, to meet the varied demands on the steam system, by auto-

matically regulating the steam supply to the pump.

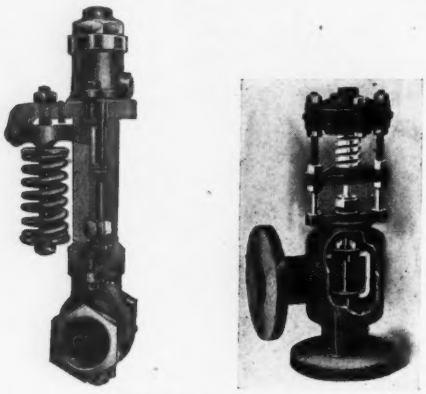
The spring instead of being on the valve stem is placed to one side of the valve and bears on the lever, which in turn imparts its tension to the stem. The spring has to follow only one-third the travel of the valve, keeping it very near one tension regardless of the demands made on the pump and resulting in uniform regulation of water pressure.

This construction permits of easy access to the stuffingbox for renewing packing and the spring can be adjusted or entirely removed without interfering with any other part of the valve.

THE WILLIAMS SAFETY PUMP GOVERNOR

The Williams Gauge Co., Pittsburg, Pa.

The Williams steam pump governor, shown in accompanying illustration, is simple in design and will control and maintain a uniform pressure in the discharge line of



WATSON PUMP GOVERNOR
WILLIAMS SAFETY PUMP GOVERNOR

boiler feed pumps, thus prohibiting the possibility of the pump accumulating high or excess pressure.

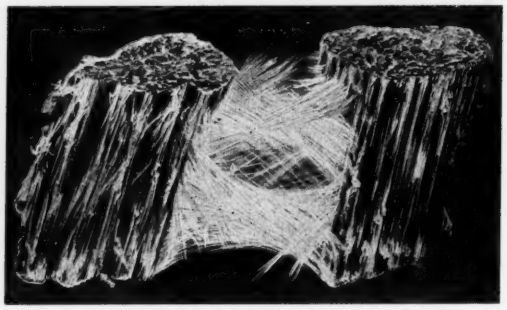
During the period of no load the positive and sensitive action of the governor maintains the pump at rest. The slightest release of the water pressure is followed by the instant response on the part of the governor, which controls the gradual starting of the pump, and the maintenance of a uniform stroke. The governor is manufactured in both angle and straightway styles, with screwed or flanged connections, and being of the diaphragm type will operate on a maximum variation of 2 lb. The method of adjustment is extremely simple, being merely the raising or lowering of the spring rider, which increases or decreases water pressure in the discharge line from the pump.

PIPING AND CONNECTIONS

In piping for feed water even more than in steam piping, it is important that all connections should be as short and direct as possible, since the friction in water pipes is greater than that in steam pipes. Elbows and tees should be avoided except where essential. It is better always to use the gate valve rather than the globe valve for feedwater lines except where the amount of water is small, as it reduces the friction in the line. The velocity of 200 to 300 ft. per minute is as high as should be allowed.

Loss due to elbows and valves depends, of course, upon the velocity of the water and on the condition of the fittings, but a reasonable approximation would be that each elbow is equivalent in the friction introduced to a length of pipe 60 times the diameter, and the loss due to a globe valve is equivalent to a length of pipe 90 times the diameter. A gate valve of full size of pipe opening will introduce but little more friction than the same length of straight pipe.

In installing piping 2 paths should always be provided for feeding the boiler, an extra path by means

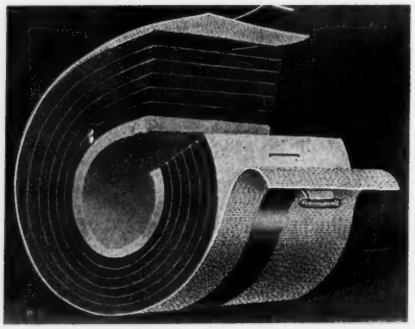


ASBESTOS IN ITS NATURAL STATE

of an injector, or else by the use of duplicate pump installations. The shutting down of a plant because of the failure of a pump valve should not be risked.

In arranging the piping valves, sufficient should be used to give flexibility to the system. The supply to each boiler should be protected by a stop valve and a check valve, the stop valve being nearer to the boiler than the check valve.

In the arrangement of blowoff piping the connections should be made to the bottom of the shell near the rear end, so that all sediment and scale may be taken out by washing into the blowoff pipe. The run of the pipe from the boiler shell to outside the setting should be protected by brickwork or by some kind of nonconducting covering so that the hot gases shall not reach the pipe or the joints in it. The water in the blowoff pipe is not



EUREKA COVERING FOR HOT WATER PIPES

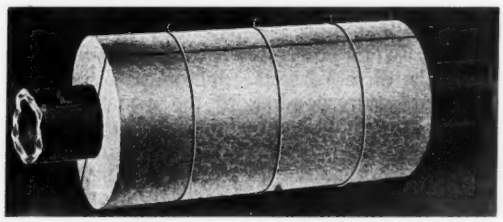
in circulation with the ordinary connection and the pipe is, therefore, particularly liable to be burned off.

A separate blowoff valve should be provided for each boiler, although the blowoff pipes may well be run beyond the valves into a common main. The matter of blowing down and of the construction of blowoff valves is treated in a separate section.

PIPE COVERINGS.

In taking the water from the heater or economizer to the boiler, evidently there will be a considerable heat loss by radiation unless some means is used to prevent. A pipe covering of asbestos or magnesia is the means usually employed. Evidently the substance of which these coverings is composed must be such as to stand a high heat without charring, and the con-

struction must be such as to offer the greatest resistance to the passage of heat. The loss from unprotected water pipes is not as great as that from unprotected steam pipes, but is, nevertheless, considerable, and some covering should always be used. Frequently on a cold water pipe it pays to use covering to prevent the drip from sweating of the pipe. In any case, the fittings as well as the run of pipe should be covered, since they offer a much larger surface for radiation in a given length than does the pipe itself.



COVERING FOR BLOW-OFF PIPE

H. W. JOHNS-MANVILLE CO.
New York City.

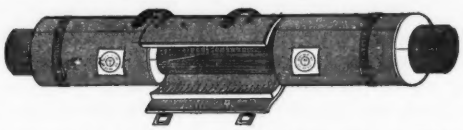
Asbestos, a specimen of which is shown herewith, in the natural state, is a fibrous mineral or rock which yields soft white fibres which are delicate but exceedingly strong and can be spun and woven. It is fireproof, acid proof and practically indestructible. Various brands of pipe covering are made by the Johns-Manville Co. for different purposes, including the 85 per cent magnesia and other brands containing 50 and 35 per cent. For blowoff pipes a sectional covering is made in sections 12 in. long, without canvas covering and held in place by wire. This is proof against deterioration by hot gases and protects the blowoff pipe from corrosion.

For low-pressure steam and hot water pipes the Perfection covering is used, consisting of ½ in. of molded asbestos and ½ in. of wool felt indented so as to form air chambers between the different layers.

The Eureka covering for this same grade of work is made of ¼-in. asbestos felt on the inside, and ¾-in. of alternate layers of asbestos and wool felt. This is made in 3 sections with canvas jacket and bands, or oil cloth jacket may be substituted.

KEASBEY & MATTISON CO.
Ambler, Pa.

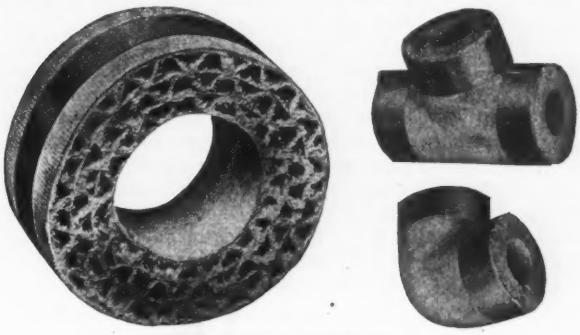
The substance named as carbonate of magnesia is the artificially prepared compound of the carbonate with the hydroxide. It is known in commerce as block magnesia and the composition is found to vary slightly with the method of manufacture. It is a smooth, white, close-grained solid, light as cork and porous as a sponge, easily molded to form covers, suitable for steam pipes and fittings. The volume of air cells in a block of magnesium carbonate is shown by weighing a block dry after immersion in water, the result proving that 93.8 per cent of the block is made up of air cells. The magnesia coverings have the advantage not possessed by other materials that the heat insulating value does not run down with age.



KEASBEY & MATTISON'S MAGNABESTOS COVERING

NORRISTOWN MAGNESIA & ASBESTOS CO.
Norristown, Pa.

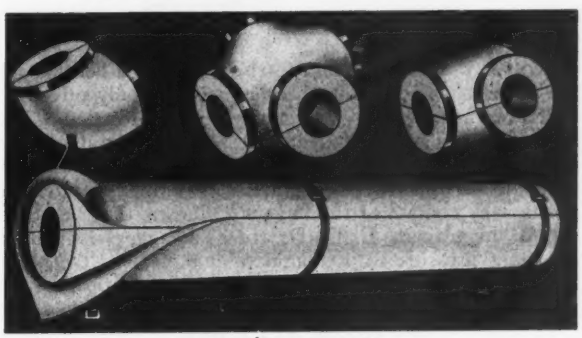
This company makes a series of pipe coverings known as the "Diamond N" products, which embraces an asbestos magnesia sectional covering, the Vim covering especially for low pressure and hot water heating, the asbestos air cell made of corrugated asbestos paper, and a line of felt covering for hot water pipes to prevent radiation and for cold water pipes to prevent sweating. The sweat-proof covering for cold water pipes is lined with tar paper.



DIAMOND N COVERING

PHILIP CAREY MFG. CO.
Cincinnati, Ohio.

These coverings are furnished for pipes ½ to 12 in. in diameter, in sections 3 ft. long, cut in halves lengthwise, and furnished with canvas jacket and bands. Special covers are made for fittings including 90 deg. and 45 deg. elbows, tees, closses, globe valves, these covers being in sectional form with canvas jacket and bands. For covering heaters, pumps, separators, etc., sectional blocks or cement is furnished, the combination of these being the most satisfactory method, and blocks being held in place by wire and the whole covered with a thin coating of cement. The material of these coverings is 85 per cent magnesia held together by asbestos, the magnesia being a better nonconductor than the asbestos, which is used only as a binder to hold the material in form. A mixture of 85 per cent pure carbonate of magnesia and 15 per cent of fibrous asbestos proves the most efficient and most durable nonconductor.



CAREY'S COVERINGS

For hot water pipes, brands known as Carey Normal and Carey Magnet are sometimes used.

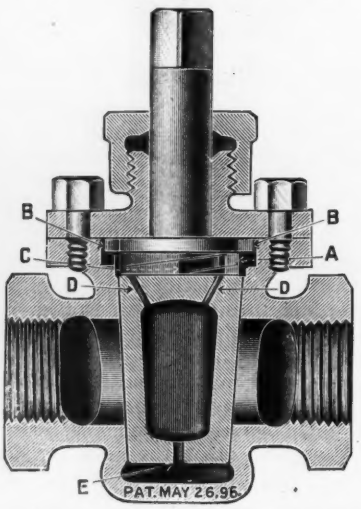
VALVES FOR FEED CONTROL.

The straightway gate valves manufactured by Crane Co. of Chicago, have iron bodies, wedge disks, and brass trimmings; the valve here illustrated has a non-rising stem. The guides on the disk and ribs in the body are so finished and fitted as to insure a good and easy movement of the disks and prevent wear of the faces, and also preventing the disks from touching the seats in the body of the valve, except at the point of closing.

The seats in the body of the valve and faces of the disks are made of brass, and the construction is such that the valve may be packed when open, without interfering with the flow of the water.

The Homestead Valve Mfg. Co., of Pittsburg, Pa., manufacture a straightway valve which is so constructed that when it is closed it is at the same time forced firmly to its seat. This result is secured by means of the travelling cam A through which the stem passes. The cam is prevented from turning with the stem by means of the lugs B which move vertically in slots. Supposing the valve to be open the cam will be in the lower part of the chamber in which it is placed, and the plug will be free to be easily moved. A quarter of a turn in the direction

CRANE STRAIGHTAWAY VALVE



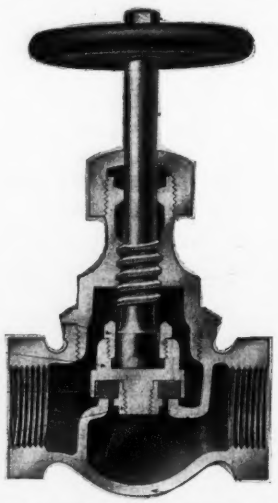
HOMESTEAD STRAIGHTWAY VALVE

of closing it causes the cam to rise and take a bearing on the upper surface of the chamber and the only effect of further effort to turn the stem in that direction is to force the plug more firmly to the seat. A slight motion in the other direction immediately releases the cam and the plug turns easily, being arrested at its proper open position by contact of the fingers of the cam at the other end of its travel. E, D, D, are balancing ports which allow the pressure to predominate at the top of the plug, holding it gently to its seat while the valve is open.

In the Jenkins Bros. valves, instead of a solid metal clapper is contained a disk holder made of brass or other suitable material, and a removable disk made of a softer material. The Jenkins disk in service presents a slightly yielding surface to the valve seat, and is flexible enough to adapt itself to any slight inequalities in the seat, thus insuring perfect contact. These valves are manufactured by Jenkins Bros. of New York, and can be repacked under full pressure when the valves are wide open. In this position the rounded surface of the lock nut seats itself against the bonnet, thereby making the joint, through which water cannot escape. It is then an easy matter to unscrew the nut and repack the valve.

The tapered double disk mechanism is the principal factor of advantage in the Nelson gate valves, which are made by the Nelson Valve Co. of Philadelphia. It consists of 2 independent, self-rocking, self-adjusting, tapered disks. These discs are suspended without any other attachments upon a powerful central wedge which is controlled by the threaded stem. In the valve body are cast 2 taper seats corresponding to the mean angle of the disks, which, without any other spreading device than the wedge on which they are carried, automatically rock into any position required for perfect seating. This is accomplished as successfully when the valve is in a horizontal or inclined position as when it is vertically placed.

The flexibility of the disk mechanism compensates for any temporary or permanent derangement of the



JENKINS BROS. BRASS GLOBE VALVE

angles of the seats that may be caused by the severest strains, or by the effect of expansion or contraction in the service for which the valve is made; and, even though 1 disk be obstructed by particles of scale or dirt, the central compound action of the wedge compels the other disk to make up tight.

The disks ride on guides that fit grooves in the valve body, and made no contact with the seats until driven completely home; thus the faces do not scrape at any point.

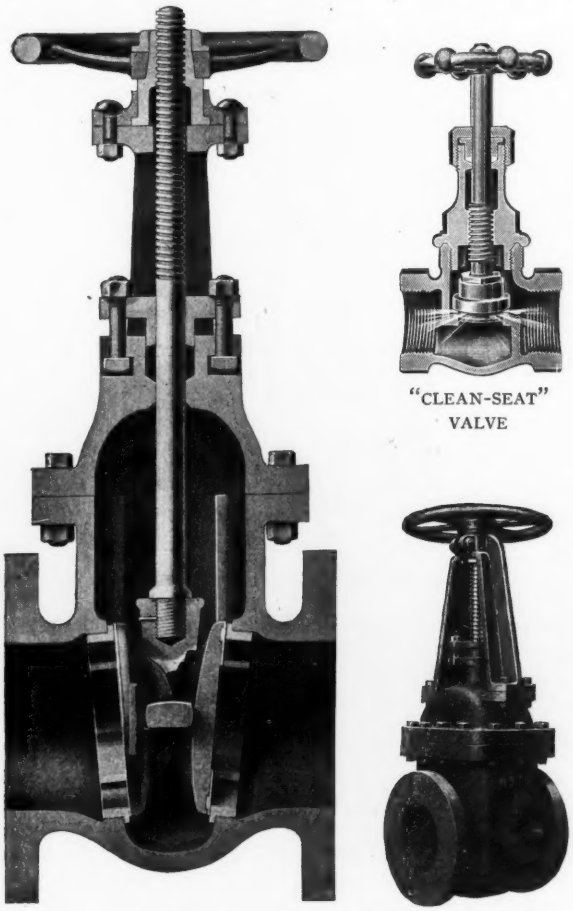
The sediment collecting in the pocket formed by the seats is crowded up between the disks, and, on the next opening of the valve, is carried up with them, and washed away.

Owing to their simplicity, it is impossible to wrongly assemble the disks; and because of their freedom in movement, they cannot jam; they are accommodated in very small space, making it possible to shorten the face to face dimensions, reducing the area exposed to the destructive elements, thus securing a valve both strong and compact.

The "Clean-seat" valve, manufactured by the Pittsburg Gage & Supply Co. of Pittsburg, Pa., is designed to do away with the troubles resulting from grit and sand lodging upon the valve seats. A hollow cylindrical extension beneath the disk fits loosely in the seat, opening just at the moment when the valve is being closed. Lugs on the inside of this extension afford support where the cylindrical wall is cut entirely through, all around, by a narrow slot just below the disk face.

In closing the valve the main flow is throttled when the disk extension enters the seat opening, but through

the slot a jet under full pressure continues to blow across the seat and the disk face all the way around, until the final moment when the closure is complete. The lugs supporting the disk extension below the slot are spiral in form, serving the double purpose of causing the disk to turn for a new seating at each closure and of giving the water a whirling motion as it issues through the slot.



"CLEAN-SEAT" VALVE

NELSON DOUBLE-DISK VALVE
PITTSBURG VALVE FOUNDRY AND CONSTRUCTION CO.'S TAPER SEAT

Thrown directly across the meeting surfaces, the cleaning jet does not cause a cutting of the faces.

The gate valves manufactured by the Pittsburg Valve Foundry & Construction Co. of Pittsburg, have bronze seats and disk rings, bronze mounted glands, solid bronze arch nuts and steel stems. The wearing faces of the wedges, in the parallel seat type, are mounted with bronze so secured as to make the wedge and mounting practically 1 casting.

The stems in the taper seat pattern are secured to the disk wedge by a method which insures that if the stem is twisted until rupture occures from tortion the break will occur at a point outside the wedge.

Where these valves are to be used in water lines it is advisable to use bronze stems instead of steel. In the parallel seat type the disks follow the seats in opening and closing and all outside screw valves can be packed under pressure when wide open.

The taper seat valves are especially adapted to high pressure piping, while the parallel seat gate valves are built for low pressure steam and water lines.

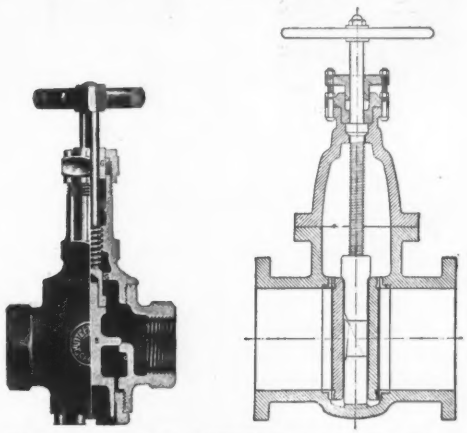
The internal mechanism of the double gate straightway valve made by the Ludlow Valve Mfg. Co. of Troy, N. Y., consists of a stem, 2 gates, and 2 beveled-faced wedges, the wedges being entirely independent of the gates or disks and working between them.

By the action of the stem which works through the nut in the upper wedge, the gates descend parallel with their seats until the lower wedge strikes the stop or boss in the bottom of the case, the gates and upper wedge continuing their downward movement until the face or bevel of the upper wedge comes in contact with that of the lower wedge. The gates then being down opposite the port or valve opening, the face of the upper wedge moves across the face of the lower wedge, bringing pressure to bear on the backs of both gates from center bearings, thus forcing them apart and squarely against their seats.

In opening the valve, the first turn of the stem releases the upper wedge from contact with the lower, thereby releasing both gates from their seats before they commence to rise, thus relieving the disks and seats from any wear or grinding effect caused by drawing them across each other.

Schutte & Koerting Co. of Philadelphia manufacture a balanced valve for use on a water supply line to an injector. Where the water is under irregular high pressure, which may at times approach the steam pressure, it becomes necessary to place a balance valve in the water supply pipe. Blows and jars in the pressure supply pipe occur through the sudden opening or closing of other outlets from the same pipe, thereby producing action of a ram. Any such irregularities or extreme pressure is most effectually counteracted by the water pressure balance valve. This valve acts at the same time as a stop and regulating valve, and when applied takes the place of stop valve.

The Ohio gate valve is of medium pattern and made of high grade steam bronze by the Ohio Brass Co. of Mansfield, O. The body is so designed as to thickness

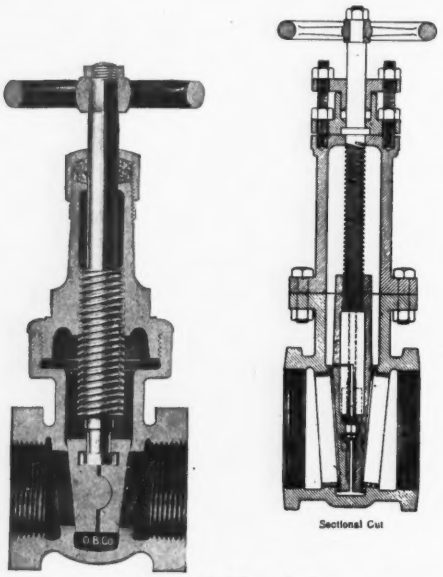


KOERTING WATER PRESSURE BALANCED VALVE
LUDLOW DOUBLE GATE STRAIGHTWAY VALVE

and distribution of metal that it will withstand pressures greatly in excess of working pressure and yet not be affected by the expansion or sagging strains met with. The disks are wedged between the seats in the body by means of a ball and socket bearing, which distributes the pressure uniformly on all parts of the seat. The disks are easily seated and will not stick in opening. The seats, steam and threads are well proportioned and will withstand hard service. Packing can be easily replaced by removing the iron hand wheel and packing nut.

The Pittsburg Valve & Fittings Co. of Barberton, O., make the standard Pittsburg iron body gate valve which is designed for 150 lb. working pressure, while the extra heavy is suited for 250 lb. In the designing of this valve not only are pressures considered, but provision is made for strains caused by contraction, expansion, water hammer, etc. The Pittsburg gate valve is made with one of the disks a solid wedge rigidly attached to the stem, while the other disk is attached to the solid wedge in such a manner that both will adjust themselves to the seats. Guides cast on the body of the valves allow the disk to clear the seats without scraping and also do not interfere with the valve finding its seat, however distorted.

The stem is threaded on the outside and is screwed and pinned into the collar, which is integral with the right hand wedge. The bosses cast on this wedge span the interlocking bosses on the loose disk. These bosses are pinned together with cotter pins so loosely that they can move in either direction upon the plug, which is set



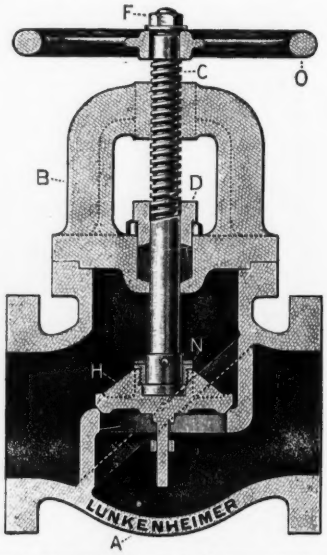
OHIO GATE VALVE
PITTSBURG IRON BODY GATE VALVE

loosely into the center pocket of both disks. These disks will adapt themselves to the seats whatever the conditions may be as to parallelism and cleanliness.

The plug is made of such length that the wedges will seat in the highest possible position which would give lap enough to make a tight closure, giving the maximum amount of wear before the wedge will bottom. The wedges are all faced with steam metal, which is forced into an undercut groove in the face of the disk. This is done by a special machine, using rolling pressure, which compacts and surfaces the metal. The seats are forced in from the inside. The projection on the side of each disk makes a pair which spans the guides cast in the center of each side of the body. The above description applies to the outside screw and yoke valves. These valves can be furnished screwed, flanged or hub end with by-pass, spur or bevel gearing, and are suitable for steam, gas, water or oil. They can also be furnished with non-rising spindles.

The Lunkenheimer flanged hub brass valve is a product of the Lunkenheimer Co. of Cincinnati, O., and is designed to meet the demand for the outside screw and yoke globe valve, one of the advantages of which is, that the threads on the stem do not come in contact with the water, which relieves them of the danger of becoming rusted. The stuffingbox can be repacked while the valve is under pressure by opening the valve as wide as possible, when the shoulder on the stem forms a seat beneath the stuffingbox.

The disk H is guided at the top by the stem C and at the bottom by a projecting pin which operates in a



THE LUNKENHEIMER FLANGED HUB VALVE

guide cast in the bottom of the valve. Should the seat wear and thereby cause the valve to leak, a new seat bearing can be formed by regrinding, to do which it is not necessary to remove the valve from the pipe.

DISCHARGING FEED WATER INTO THE BOILER

The method of discharging feed water into boilers has 2 important bearings upon the economy in the boiler room; these are to help increase circulation and to deposit the sediment where it is least harmful.

Before the water is discharged, it is well to lead the pipe around through the water space a turn or two in order to heat the water so that when it comes in contact with the heating surfaces it will cause no serious contracting strains in the boiler metal. When finally discharged from the pipe, it should be in that part of the boiler where the least evaporation takes place and in the direction which is the natural circulation for the water in the boiler at that point. By this simple arrangement the circulation is increased and the deposits are washed to that part of the boiler just over the blowoff where they can do the least damage, and are easiest removed.

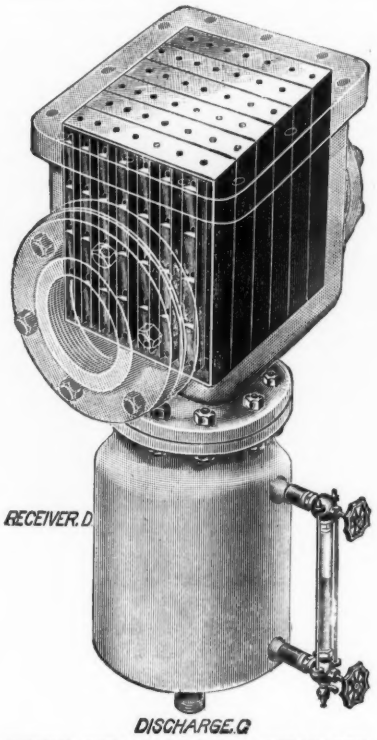
TOO LATE FOR CLASSIFICATION

BUNDY STEAM AND OIL SEPARATOR.

American Radiator Co., Bundy Dept., N. Y. City.

The process of extraction is effected by the series of separating plates, 6 or more in number, placed in a vertical position in the body of the separator through which the steam must pass. These plates consist of upright hollow columns with openings at regular intervals for the admission of water, oil, etc., to the central duct, which drains downward to the receiver. The columns in this space are set staggered, in other

words, 1 column is set directly behind the open space between the 2 columns of the plate in front. The steam takes a zig-zag course and all of it comes into direct contact with the intercepting columns, insuring thorough treatment and complete removal of the oil and



BUNDY STEAM AND OIL SEPARATOR

water. The plates are flanged at the bottom to form a barrier between the body of the separator and the receiver, which effectually prevents the picking up of water and oil in the receiver by the steam and carrying them forward into the steam pipe.

THE B. AND K. DIE GRINDER.

In order to cut threads on pipe correctly it is important that the dies should be of the correct shape

THE B. & K. DIE GRINDER

and properly ground. This implies the correct rake and clearance, without which the threads are torn or stripped. Spite of this fact, dies usually receive but little attention, largely because most shops have no equipment for properly grinding them.

Dies ground as is usual without regard to angle, are never twice alike, require much power to operate and frequent recutting, difficulties which can be largely overcome by proper grinding.

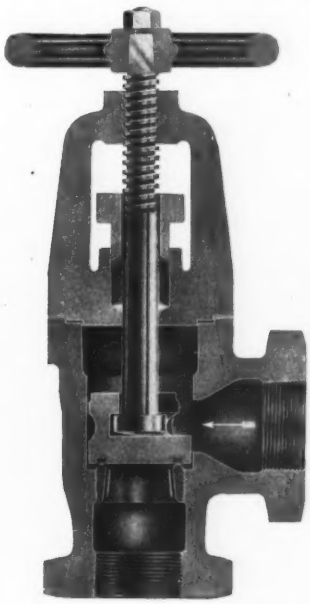
In the tool herewith illustrated has been produced a simple and convenient machine which can be operated rapidly and requires no skill. On one end of a spindle is a specially formed wheel beneath which is a platen to which the die is clamped; the platen moves back and forth by means of a lever and at the same time the die is gradually raised against the grinding wheel by the operation of the hand wheel. As the gage on the platen is adjustable to any angle, straight thread dies as well as tapered pipe dies can be ground. The shape of the wheel gives the die the correct angle of rake, a wheel template serving to assist in dressing the wheel to the correct angle, and a dresser being provided to do the work.

On the other end of the spindle is a cone-shaped wheel for grinding the lead of the dies. The special wheel may be removed and a straight wheel which is furnished with the machine substituted, when the grinder is ready to sharpen other tools. The total weight is 425 lbs., the driving pulley 16 in. diameter by 2.5 in. face and the speed 830 r. p. m. The machine is made by Bignall & Keeler Mfg. Co. of Edwardsville, Ill.

CRANE BLOW-OFF VALVE.

Crane Co., Chicago, Ill.

The valve here illustrated has been used extensively for many years and has given good satisfaction.



CRANE BLOW-OFF VALVE

It is durable, withstands well the cutting effects of scale and sediment and the wearing parts are easily removed and replaced. These valves are made of extra heavy ferro steel and fitted with hard metal seats.

GAGE COCKS SHOULD BE TRIED by sound and not by sight, as the latter is liable to be deceiving.

PRACTICAL ENGINEER

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FOREWORD

We present to you, our readers, herewith our best wishes for a new year of happiness and prosperity and also our first contribution towards it. We feel certain that you will appreciate this issue and will find it of value. We have endeavored to bring to you information wherever found, which would be of help to you. We would acknowledge particularly indebtedness to some of the books which have been published on the subject, including Christie's Boiler Feed Waters, Kershaw's Gas, Fuel and Water Analysis, and Collet's Water Softening.

We wish to thank, also, all those who have assisted us by the furnishing of articles, data, and illustrations, and by the revision of manuscript, for the part which they have taken in making this issue a success.

From another page you will get an idea of plans for the coming year which will give you a volume fully equal to the promise of the first issue. Of necessity all matter except that pertaining directly to the subject in hand has been omitted from this issue, but the interesting material accumulated for the different departments will all be found in the issues to come.

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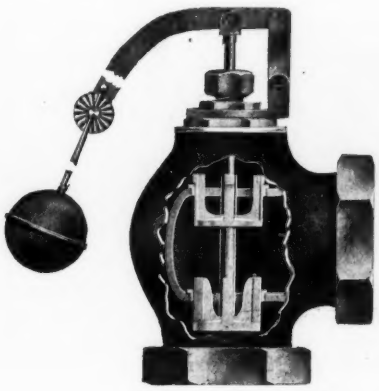
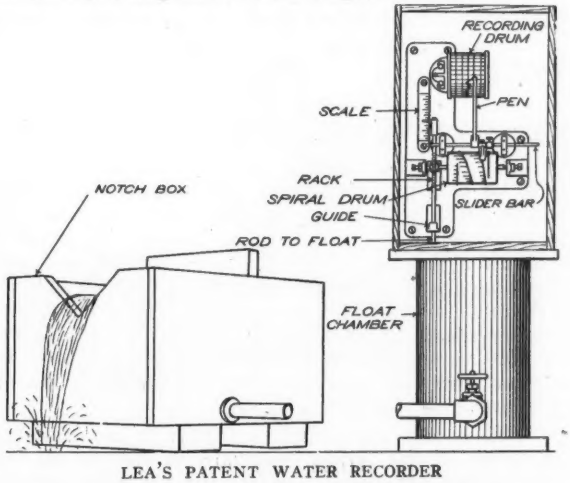
DAVIS FLOAT VALVE

The Davis float valve is designed to control automatically the admission of water into a tank or reservoir by the rise and fall of the water level, and is frequently employed on open feed water heaters. The inner valve is of the double-seated piston type and is perfectly balanced. Directly connected to it by means of a stem and lever is a float which controls its movement. In a normal position this inner valve is open and allows the water to flow from the inlet pipe into the tank. When the level in the tank rises to a point of contact with the float the valve closes.



DAVIS FLOAT VALVE

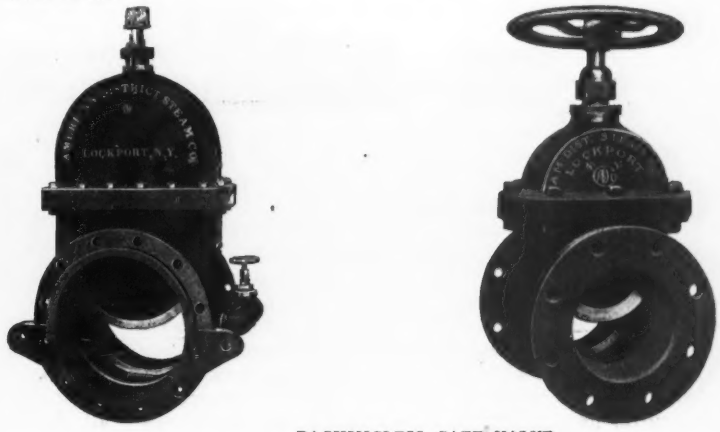
The distinctive features of this valve are its full area of the inlet pipe through the seats, giving it a large capacity, and the direct connection of the inner valve to the float which assures positive control. The small corrugated wheel at the end of the lever provides for the adjustment of the float at any desired angle. Standard valves are made for cold water at any working pressure up to 200 lb.; valves for hot water are made to order. This valve is made in both globe and angle patterns by the G. M. Davis Regulator Co., Chicago, Ill.



LEA'S PATENT WATER RECORDER

LEA'S PATENT WATER RECORDER

The object of the instrument shown in the illustration, is to measure and record graphically variations in the rates of flow of water, the records being produced in such a way that it is easy to determine the total volume of water passed during any interval of time. The tank or notch box through which the water flows, or some chamber in connection with it, contains a float rising and falling with the level of the water above the weir. This float is directly connected by means of a stem to a rack which gears into a small pinion upon the axis of a drum. Upon the body of the drum, is wrapped the spiral wire coil, which operates a slider bar carrying the recording pen. The recording drum is operated by clock work, and the spiral wire coil is of such shape that the record shown on the drum gives the flow of water through the weir at any instant. From this record, the total volume for any given length of time, can easily be calculated. The device is one of the products of The Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.



PACKINGLESS GATE VALVE

PACKINGLESS IRON BODY GATE VALVE

American District Steam Co., Lockport, N. Y.

These gate valves have been especially designed for use in underground heating systems and are of particular value for use in underground or in station equipment on account of not having to make repairs. The bodies of these valves are made of the best quality of close grained iron and they are mounted throughout with a high grade of bronze.

The principal feature of these valves is the fact that there is a third seat on the stem, which positively prevents leakage when the valve is fully opened or closed. A small amount of packing is used in the stuffing box to prevent the escape of water when the valve is being opened or shut.

Another distinctive feature of these valves is the area of the opening through the valves. It is full size without the gates projecting, and thereby reducing the efficiency. These valves are furnished either with hand wheel or nut as shown in the illustration, and manufactured for any pressure.

FOR CLOSING LEAKS in iron pipe, mix 5 lb. coarsely powdered iron borings, 2 oz. powdered sal ammoniac, 1 oz. sulphur and water sufficient to moisten. Use as soon as mixed, for it hardens rapidly. If time can be allowed, the setting will be firmer if the sulphur is left out.

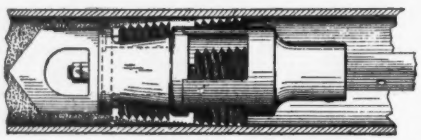
DO NOT THINK OF YOUR FAULTS, still less of others' faults; in every person who comes near you, look for what is good and strong; honor that; rejoice in it; and as you can, try to imitate it; and your faults will drop off like dead leaves when their time comes.—*Ruskin.*

THE CASADAY POWER-DRIVEN TUBE CLEANER.

This machine is shown assembled in Fig. 1. It is driven by a rotary engine, using steam or compressed air, the engine being capable of developing 10 hp. with 80 lb. pressure. The engine drives the cutter head and shaft at the rate of 150 r. p. m., the cutters being forced out against the scale by an ecentric motion working the pins on which the cutters revolve out from the inclined slots. The cutters are of screw form so that they draw themselves into the scale and are self-adjusting to all conditions and shapes of tubes. Three minutes is the time allowed by the makers for the cutter head to pass through a tube and one minute the time for a man to change the machine from one tube to another.

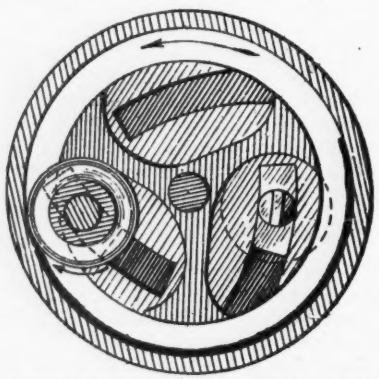
THE CASADAY POWER-DRIVEN TUBE CLEANER

Between the cutter head and the engine extends a square, hollow, shaft made in sections and arranged so that the sections slip together automatically and are uncoupled automatically when pulling out the cutter head.



THE CASADAY CUTTER HEAD AT WORK IN A TUBE

For use in curved tubes, a flexible square shaft is provided which will go around a curve having a radius of 12″ or larger. As the cutters wear down, they keep their conical shape and when the teeth at the rear end are all gone, the cutters are turned end for end and kept in use until again worn down. So positive is the action that one passage of the cutter head through a tube cleans off the scale clear to the iron without scratch or injury, leaving a smooth, polished surface.



SECTION OF TUBE AND CUTTERS SHOWING SLOTS AND PINS

When the engine is stopped the cutter head collapses and can be removed without difficulty. All parts are interchangeable and made of material especially adapted for the construction.

The engine has but two working parts and is condensing, all steam being condensed and used to wash out the tube which is being cleaned; 10 ft. of ¾-in. steam hose forms the connection to the steam line and this is sufficient to allow the cleaning of two boilers from a steam connection located between them. A water cock connection from ¾-in. hose gives the means of condensing the steam and washing the scale out of the way of the cutter head, a 3/16-in. stream of water being all that is required.

For horizontal boilers, the connection between engine and cutter shaft is by spur gears. For vertical boilers, this connection is by bevel gears, which makes an arrangement of engine taking up about 5 in. when inside the boiler. By the use of sectional shaft, a long platform is unnecessary, 4 ft. giving sufficient room to operate.

Fig. 2 shows the cutter head at work inside the boiler tube and Fig. 3 the cross-section of tube and cutters with the inclined slots and pins by which the cutters are forced out against the scale. The machine is built in sizes for tubes from 2 to 4.5 in. diameter, all parts being interchangeable. Larger sizes are built to order.

W. L. Casaday, president of the South Bend Chilled Plow Co., is the inventor of the device, which is made by the W. L. Casaday Manufacturing Co., of South Bend, Ind.

LARGE VALVE ORDER FROM GOVERNMENT.

Last June the Isthmian Canal Commission invited bids for a large quantity of bronze globe and angle valves fitted with seats and disks that were capable of being renewed. Considerable competition resulted and after the authorities at both the Isthmus and Washington had carefully considered the bids submitted by a number of manufacturers, they decided, a few days ago, to place the order comprising upwards of 7000 valves, in sizes ranging from ¼ to 3 in. inclusive, for the Lunkenheimer "Renewo" renewable seat and disk regrinding valve.

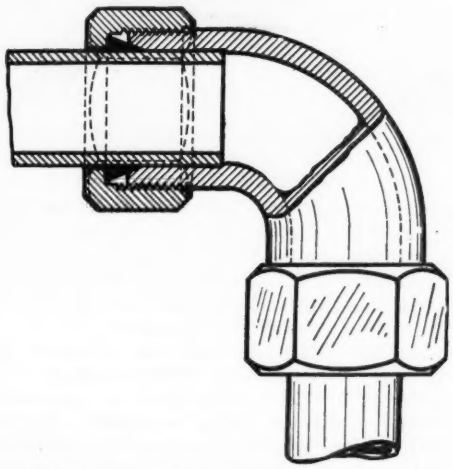
This is considered quite a tribute to the efficiency of design of this article, especially in view of the fact that it has not been upon the market quite as long as some other well known makes.

This valve is practically everlasting, inasmuch as every part that is subjected to any possible wear can be easily, quickly and cheaply renewed,—a most desirable feature. These valves are guaranteed for 200 lb. working pressure and are manufactured by The Lunkenheimer Co. of Cincinnati, Ohio, having branches at New York, Chicago and London, Eng.

THE NEW UNION-CINCH PIPE FITTING.

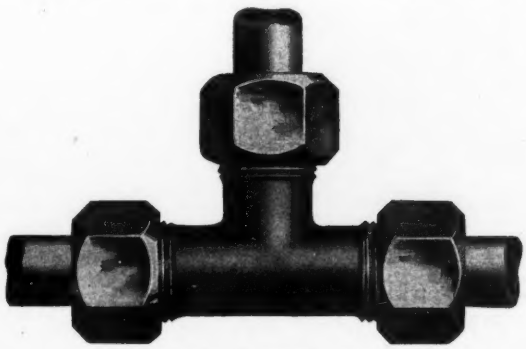
Those who have had actual experience in trying to make up a neat, mechanical looking job of small piping with the ordinary threaded pipe and tapped fittings, will remember having wondered why there had not been invented some more practical way in which to accomplish the work.

In the first place, it seems probable that the work of threading pipe and getting a good fit for the threads could be accomplished at a factory or in the shop



SECTION VIEW OF A UNION CINCH ELBOW

much better than it is often done by means of a set of dies in the hands of more or less inexperienced workers, who are often obliged to thread a piece by holding it with a Stilson wrench while they try to run the die in by hand. And after all the care possible has been exercised in making up a job, where the pressures are rather severe, it is usual to find a number of leaks; and we have all noticed that these leaks usually occur where it is least convenient to get at them and give the pipe another turn to take them up.



A UNION CINCH TEE

Some of our friends in Milwaukee consider that they have gotten out something that gets around the majority of these difficulties; they believe that it is more practical to do the work of threading in the shop than it is to do it in the field; and accordingly they present an interesting line of pipe fittings, which they term the Union-Cinch type.

These fittings are made in sizes corresponding to standard iron pipe up to 1 in., and are especially designed for use in connection with the oil pumps and oilers manufactured by the Sight Feed Oil Pump Co., who are manufacturers of these new Union-Cinch fittings.

It is possible to use ordinary rough pipe with these fittings, if care is exercised in filing the ends of the pipe round and smooth; but the builders of the fittings are prepared to furnish smooth drawn steel tubing corresponding to the iron pipe sizes on the outside diameter. This tubing has No. 16 gauge wall in the ¾ and 1 in. sizes, and 18 gauge wall in smaller sizes, and has, therefore, a very much larger carrying capacity than ordinary pipe. In fact, their ½-in. pipe will carry almost as much as the ordinary 1-in. iron pipe. This steel tubing is very cheap, is thoroughly annealed, readily bent, and when it comes to paying the bill for labor and putting up a job of pipe work, the Union-Cinch system brings to light a number of strong arguments in its favor. In the first place, a hack saw and monkey wrench are all the tools that are required, except where some very fancy work has to be done, in which case a bending rig of some sort is convenient.

Each fitting is a union, and the piping may be taken apart at any point where a fitting is inserted. The joint is made by screwing down the outside nut, which presses a thin, tapered shell into the annular cavity around the pipe, between it and the fitting, as shown on the sectional cut. These nuts may be pulled up good and hard and the soft cone shell will make an absolutely tight joint around the tubing, which is good for 1,000 lb. pressure per square inch; or, in fact, is absolutely tight under any pressure that the tubing will stand.

Where it is desirable to have a nice looking job, brass pipe may be used; although in cases where nickel-plating is done, the steel tubing will nickel-plate just as nicely as brass pipe and is much cheaper.

This type of joint may be taken down and made up again any number of times without any trouble, and has a number of attractive features which will rapidly lead to the adoption of the Union-Cinch system in the troublesome work of piping up oil pumps, gravity oiling devices, gauges, drop pipes, etc., and especially in such work around ammonia handling machinery, where this steel tubing and fittings made of steel are especially valuable because of the readiness with which they may be made up perfectly tight against the escape of ammonia gas.

CYCLONE TUBE CLEANER AND NORIVET HEAD.

The Cyclone cleaner is of a new design, and while it resembles the well known type Liberty cleaner, the motor is entirely different from the Liberty turbine. The difference is, the motor is a rotary engine and is driven by the pressure of the steam or air against the cylinder blades. When in operation, the machine is connected up to an air supply placed in the tube, and after it has advanced a short distance a small stream of water is permitted to play in the tube being cleaned, for the purpose of keeping down the dust created by the cutting tool, and also to prevent the tube from heating, especially when steam is used.

These machines work very satisfactorily with an air pressure of 50 to 60 lb., and when steam is used, a pressure of 25 to 50 lbs. is all that is required.

Inside the cylindrical body of the cleaner is an eccentrically mounted shaft, carrying in a longitudinal slot a pair of blades so perfectly balanced as practically to eliminate all friction. These blades are also

self adjusting for wear. This balancing of the blades is the secret of this successful solution of the problem of constructing a satisfactory rotary pressure motor.

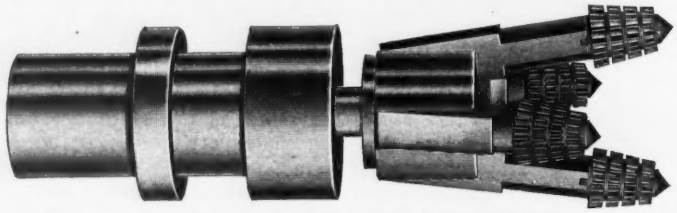
Air enters the cylinder through longitudinal ports and drives the blades, which move back and forth, through the slot in the shaft. The ends of the cylinder are removable steel heads held in place by long screws which pass through the cylinder walls from one head to the other. This construction is rigid, simple and makes examination easy. End wear on the blades is prevented by making the surfaces of the heads next the blades very hard.

In the path of the air supply is a special lubricator which admits a constant supply of oil to the cylinder, the oil being carried into the bearings by the pressure inside the cylinder. Around the rear bearing is an air chamber which is vented to the atmosphere so that oil is carried from within out to both front and rear bearings, avoiding the use of exterior oil holes and preventing the entrance of dirt and dust.

The Cyclone cleaner is made also with a small body, having the blades arranged at right angles for use in tubes as small as 1.5 in. diameter, and for bent tubes has a universal joint between the cutting head and the motor.

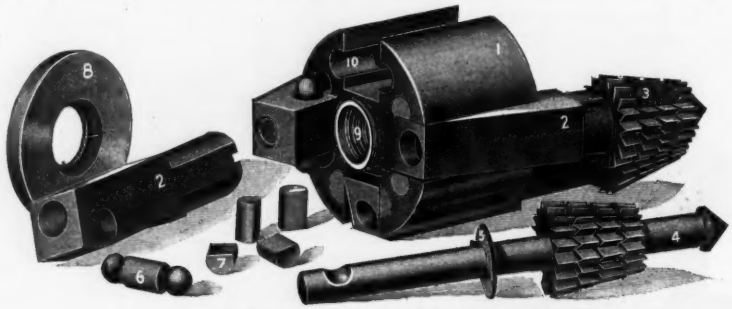
The Norivet head has the great advantage that it can be taken apart for replacing a worn part in less than 1 minute by anyone, however unskilled, without a single tool of any kind. The parts are heavy and have long life and the construction is simple.

In the partly assembled view, the head 1 is slotted as usual, but in the sides of the slots are recessed grooves 10 which fit the ball ends of the trunion 6. In putting together the head, the cutters 3 are slipped on the cutter pin 4 and are followed by the lug washer 5, whose lugs fit into the end of the arm 2. The cutter pin is inserted in the arm so that the milled recess near the left-hand end comes opposite the trunion pin hole in the arm, so that the trunion fitting into this recess holds the cutter pin into the arm. The ends of the trunion are now slipped into the grooves 10 and pushed to a seating, the lock plugs 7 slipped in after them and the lock washer 8 screwed on to the thread 9, holding the whole head firmly together. Taking down the head is, of course, just the reverse operation of assembling it. With this head the operator has no need to leave his work to replace a part or "fix" a machine. The Norivet head can be attached to all forms of cleaners. It is made by the Liberty Manufacturing Co. of Pittsburg, Pa.



THE CYCLONE TUBE CLEANER EQUIPPED WITH NORIVET HEAD

THE CYCLONE CLEANER FOR BENT TUBES



THE NORIVET HEAD PARTLY ASSEMBLED

NEWS NOTES

GRANT W. SPEAR, who for many years has been Vice-President of the Dearborn Drug & Chemical Works at Chicago, took charge Nov. 1 of the general Eastern offices of the company, at 299 Broadway, New York City, as vice-president and eastern manager, Mr. McVicker being no longer connected with the Dearborn Co.

MELDON H. MERRILL, who, as salesman for the Westinghouse Electric and Manufacturing Co., has been active for some years past in promoting the introduction of electric drive among the textile mills in New England, recently resigned his position with that company and has taken up similar work in connection with the Boston office of Allis-Chalmers Co., which has become a large factor in building power machinery for textile mills because it is in a position to offer any type of prime mover required, and to install the complete electrical equipment, including motors.

JOHN POWERS, formerly General Superintendent of the Sterling, Dixon and Eastern Electric R. R., at Sterling, Ill., has been appointed Chief Engineer of the Wisconsin Electric R. R. Co., Oshkosh, Wis., also of the Eastern Wisconsin Railway and Light Co. of Fond du Lac.

JULIUS A. GERWEN has recently been appointed a district representative of the Sight Feed Oil Pump Co., at Duluth, Minn. Mr. Gerwen's offices are located at 226 West Michigan St., where he will be pleased to show those interested a model of the working mechanism of the Richardson Pump, as well as several of the pumps themselves.

W. B. MCVICKER has resigned as Vice-President and Eastern Manager of the Dearborn Drug & Chemical Works.

Mr. McVicker's many friends and acquaintances will be interested to know that he has incorporated

the W. B. McVicker Co., 115 Broadway, New York.

A new and complete laboratory and factory have recently been completed giving exceptional facilities for general analytical work, and the manufacture of high-class products. A specialty will be made of scientific preparations for treating boiler feed-waters and hydraulic systems, also high-grade lubricants.

The personnel of the company includes Charles M. Eddy, Albert E. Carpenter, Joseph F. Hammill, William J. Schatz, G. Frank Duemler and Frank J. Zink; names well known in business and professional circles; men who have long been associated with Mr. McVicker.

AT CLEVELAND, O., the Sight Feed Oil Pump Co. has appointed L. G. Finlay as Ohio representative, his territory being the entire state of Ohio. The many friends of Mr. Finlay and of the Richardson Sight Feed Oil Pump will find a welcome at 710 New England Building, where working models and a number of the pumps themselves will be on exhibition.

D. D. PENDLETON has been appointed exclusive representative for the Pittsburg district for the Bartlett Systems for softening and purifying water made by the Northern Water Softener Co. Mr. Pendleton was formerly associated with the Westinghouse Co. and has a broad experience and a thorough knowledge of power plant equipment. He will esteem it a favor to be given an opportunity of explaining to interested parties the merits of the Bartlett apparatus. Mr. Pendleton's address is 574 Frick Bldg. Annex, Pittsburg, Pa.

THE BABCOCK & WILCOX CO. has purchased from the Rust Boiler Co. its patents and plant located at Midland, Pa., and will continue the manufacture, at that point, of the Rust water-tube boiler.

HERBERT E. STONE has just become connected with the Dearborn Drug & Chemical Works, as manager of sales in the Eastern department, with headquarters in New York City. Mr. Stone was formerly President of the N. A. S. E., and recently manager of the Pittsburg office of the Chapman Valve Co. Mr. Stone will have associated with him a corps of able assistants. The Dearborn company is to be congratulated upon the splendid addition to its selling force.

CATALOGS RECEIVED.

MOUND TOOL & SCRAPER CO., of St. Louis, is getting out a handsome nickel-plated anvil paper weight which will be sent to every engineer who orders tools from them during the month of January. The company sends out a handsome postcard showing its new office front at 1606 N. Broadway, St. Louis.

VALVES is the title of a new catalogue issued by the American Steam Gauge & Valve Mfg. Co., of Boston, which is 90 pages, describes fully with illustrations, sectional views, dimension and price lists, the American safety valve of various types for stationary, marine and locomotive work; also American water relief valves, cylinder relief valves, vacuum values, and mufflers.

DESCRIBING THE HOPPES SYSTEM a handsome catalog 6 by 9 in. with a beautiful embossed cover has just been issued by the Hoppes Manufacturing Co. of Springfield, Ohio. This shows fully the Hoppes Separators with and without receiver, the Hoppes Oil Eliminator and cast iron exhaust heads; also the Hoppes Feed Water Heaters and Purifiers. It is an interesting book and can be had by writing to the company for a copy.

A CONVENIENT DAILY MEMORANDUM calendar for 1909 is issued by The Bourse, Philadelphia. This will be found a help to those who have to make appointments in advance and need something to keep track of them.

OUR NEW PRODUCT describes in detail the Multivane Fans recently perfected by the B. F. Sturtevant Co., of Hyde Park, Mass. The bulletin is No. 158 and gives full illustrations of the new fans and the turbines and motors which are used to drive them. Incidentally it illustrates the Sturtevant economizers, heating apparatus, forges, dust collectors, high-pressure blowers, and exhausters and blast gates.

J-M PIPE AND BOILER INSULATION gives a key to the descriptions found in the new catalog No. 100 issued by the H. W. Johns-Manville Co., New York City. These pipe and boiler coverings are made of asbestos and magnesia, and the catalog, which contains 70 beautifully printed pages, gives a very definite idea of how the different coverings are made and what they will do. It shows not only the straight pipe coverings but coverings for flange joints and for fittings. These coverings are made for steam pipe, water pipe, brine and ammonia pipe, and are put up also in sheets and blocks for covering boilers, flues and heaters.

Another substance which may be used for this purpose is the insulating cement, which is put on like a mortar over the sheets and blocks, giving a perfectly smooth surface. A novelty is the cement for covering house furnaces, another one is asbestos stove lining and still a third Vitribestos smoke stack lining.

The book has a lot of interesting facts and a lot of attractive illustrations. It is the finest book we have seen on the subject of pipe covering and will be supplied to those interested on request.

SCULLY'S BLUE BOOK is always of interest to those having occasion to use hardware. Scully Steel & Iron Co., of Chicago, carries in stock, all kinds of steel and iron shapes, ready for immediate delivery, and in this Blue Book, which contains 240 pages, a complete listing is made of such shapes, and of a great number of special tools for use in the machine shop and power plant, such as pipe wrenches, pipe threading machines, tube cutters, cleaners, drills, hack saws, blacksmith tools, chain blocks, punches and boiler makers' equipment; and besides these listings, the book includes 60 pages of useful information in regard to strength of steel and iron shapes and the proportion of riveted joints. Each month, in addition, a current Stock List is sent out, showing exactly what is on hand in the warehouses, and what sizes may be out of stock, so that delay can be avoided when placing orders.

THE BLACKBURN-SMITH FEED-WATER FILTER and Grease Extractor has been chosen for the new Colliers, Mars, Hector and Vulcan, now being built for the U. S. Navy by the Maryland Steel Co. These ships have the highest class of equipment, and every possible protection. The filters are to be placed in the feed lines, so that every drop of water entering the boilers, is subjected to the double filtration, characteristic of the Blackburn-Smith Filter. It is figured that by removing the oil and grease particles from the condensation, the filters will repay their cost in a short time by decreasing boiler repairs, and increasing fuel economy. These filters are also excellent for protecting the boilers of stationary plants from floating particles of oil, grease, mud, etc. in the feed-water. They are made by James Beggs & Co., 109 Liberty St., New York, who are distributing an interesting booklet on Feed-Water Filtration.

TRADE NOTES

IN ADDITION TO THE SIZES OF Rochester lubricators which for a long time have been manufactured by Greene, Tweed & Co., of New York City, new sizes have recently been designed, including a 2-pt. single feed, a 2-pt. double feed, a ½-gal. single feed and a ½-gal. double feed. This makes the line now manufactured by that company run from ½-pt. up to 1 gal. in the single feeds, from 2 pt. to 2 gal. in the double feed, from ½-gal. to 2 gal. in triple feed, ½-gal. to 2 gal. in quadruple feed, 2 gal. in quintuple and in sextuple, and in special lubricators the 3-pt. double, 1-gal. double, 1-gal. triple and 1-gal. quadruple feeds with 2 compartments.

THE AMERICAN SOFTENER CO. of Philadelphia, Pa. engineers, designers and manufacturers of water softening and purifying plants, reports among its important unfilled orders, several water softening plants for the Seaboard Air Line Railroad in Florida. Softeners for Joseph Brakeley, Freehold, N. J., Eureka Mining Co., Joplin, Mo., and the Ismert-Hincke Milling Co., Kansas City, Mo., and special softening apparatus for the City of Tulsa, Okla. Some of the unfilled orders for filtering plants are as follows: 1,000,000 Imperial gal. per day for the Consumers' Gas Co., Toronto, Ont.; 1,756,500 gal. per day plant for the Patchogue Mfg. Co., Patchogue, N. Y.; 250,000 gal. per day plant for Wm. H. Grundy, Bristol, Pa., 400,000 per day plant for Kanawha & Michigan Ry. and an addition to the filter plant at the State Hospital for the Insane, Danville, Pa., equal to a daily capacity of 1,000,000 gal.

THE GROWING DEMAND for Bird-Archer Boiler Compounds in Hawaii has made it necessary for the Bird-Archer Co. to open a branch office there, which is located in Suite 42, Alexander Young Hotel, Honolulu, and is in charge of Mr. J. P. Lynch, an experienced marine engineer, and also an authority on boiler troubles in stationary plants. Bird Archer Compounds were first introduced into Hawaii for use in connection with the boilers on sugar plantations, a class of work which has also given them great prestige in Cuba. P. B. Bird, president of the Bird-Archer Co., who is now in Hawaii, writes that boiler feed waters on the islands are so bad that if no preventive measures are employed it becomes necessary to remove scale by mechanical methods at least once every 30 days.

CHAIN BLOCKS, ELECTRIC HOISTS, TROLLEYS AND CRANES is the subject of a new publication issued by the Yale & Towne Mfg. Co., of New York City. The Yale & Towne Triplex Chain Block is a most effective device for lifting heavy loads easily and the method of its operation is fully explained in this booklet; also the working parts are shown, capacities and sizes and processes are given. Other apparatus taken up in the 70-page book is a line of single I-beam traveling cranes, a system of overhead track and details, a system of crabs and winches for derricks, and a system of electric hoists. It is a handsome book, as well as instructive.

WANTED

"Positions Wanted" advertisements not exceeding 50 words for subscribers to Practical Engineer will be inserted twice free of charge. "Help Wanted" and special advertisements 25 cents a line.

POSITION

as second-class engineer in a stationary or electric light plant, or will take a job at firing, also in a Corliss engine shop. Have had six years' experience with steam engines. Can give references or come on trial. Location not important. Hold second-class Minnesota license. Address Fred W. Dammann, Lock Box 200, Sanborn, Redwood county, Minn. 13-2

POSITION

Experienced engineer, holding second-class Massachusetts license wants a position. Address John E. Ware, 45 Broad St., Salem, Mass. 13-2

POSITION

As chief or second engineer, without firing, in a manufacturing or power plant. I am 38 years old, with family. Have had 16 years' engineering experience. Best of references; willing to locate anywhere. Address Box 91, Practical Engineer. 13-2

POSITION

By young man as oiler or helper in an engine room. Have finished the study of boilers in my I. C. S. steam engineering course. Age 19; no experience, no bad habits, good worker. Give full particulars. Address Wm. D. Myers, 369 East Union St., Circleville, Ohio. 13-2

POSITION

Engineer now employed by large manufacturing company wishes to make change. Experienced on all types of modern boilers and engines, A. C. and D. C. generators, gas engines and storage batteries. Recommendation from present employer. Prefer to have full charge and be responsible for economical operation of plant. Address Box 92, Practical Engineer 13-2

POSITION

By Chief Engineer, seventeen years' experience in power plants, A. C. and D. C. machines, compound and Corliss condensing engines. Also have practical business education. Address L. J. R., 218 Pennsylvania Ave., Elmyra, N. Y. 11-2

POSITION

First-class engineer wants position in or near Nevada or South Dakota. Fifteen years' experience as assistant and chief. Graduate of technical school. Experienced with steam, electric and refrigerating machinery, and with pumps. Strictly sober and steady. Thirty-eight years old. Very best references. Address J. V. Kilkin, 207 Prospect Ave., Syracuse, N. Y. 11-2

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A high grade salesman with experience in selling machinery and equipment in the power plant field. Must have a record showing ability to develop and close sales with big industrial establishments, consulting engineers and architects. Preference will be given to an ex-Allis-Chalmers or Westinghouse man, but consideration will be given all applicants. An excellent opportunity for the right man.

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Direct-connected engine and generator, 100 kw. direct current; good as new. Address Monarch Machine Works, Altoona, Pa. 13-1

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60 steel storage tanks, 6,000 gallons' capacity. Good as new. Double riveted, extra well built. Suitable for storage of oils, waters or liquids of any kind. 100 steam pumps. Get our prices on engines, boilers and electrical machinery. All sizes and kinds. Chicago House Wrecking Co., 35th and Iron Sts., Chicago. 4 tf

SALESMAN WANTED

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To introduce our New Commercial and Statistical State Chart for office and general use. The work is congenial and profitable, the earnings being according to your ability. A thorough training is given before the work is started. Rand, McNally & Co., Chicago, Ill. 10-5

SALESMAN

We want a good Salesman in every city in the United States, to handle Ideal Metallic Packing. Manufacturers' Agents and Engineers preferred—Ideal Metallic Packing Co., South Stillwater, Minn. 4 tf

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The new revised edition of the Modern Engineer's Hand Book. A $2.50 Book by mail on receipt of 50 cents. Be quick. Address, W. H. Ermentrout, 514 Elm Street, Reading, Pa. 4 tf

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To make big money selling Incomparable "ZIZ" Hand Soap. A 10-cent can will instantly remove more dirt and stains from the hands than four cakes of any soap made, and it will not injure the most delicate skin. Small sample free. Byram Mfg. Co., Box 3133, Boston, Mass. 4-1

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C. L. Parker, Late Examiner, U. S. Patent office, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. 186 McGill Building, Washington, D. C. 4 tf